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# CYANOPHYTA

# I. C. A. R. MONOGRAPHS ON ALGAE

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# FOREWORD

In December 1956, the Indian Council of Agricultural Research initiated a comprehensive programme of monographs on ' Algae in India '. The importance of algae as fish food as well as the role which they play in soil biology is well recognised. Though a good deal of research work has been done in India on the algal flora, this work lies scattered in numerous journals. It was felt that time has come to compile the work which has so far been done in the form of monographs. This is a type of work which can only be undertaken by a group of specialists. Accordingly a meeting was called at which all leading workers on algae in India were invited and assignments for compiling monographs on the various subjects relating to algae were made.

The task of compiling a monograph on blue-green algae of India was entrusted to Dr. T. V. Desikachary of the Department of Botany, University of Madras. A study of blue-green algae is not merely of academic interest but has also a bearing on agriculture. It is well-known that agricultural soils in India are poor in nitrogen. Therefore reference may be made to what are called soil algae because they favourably affect the soil fertility and hence are of importance to crop production. Some blue-green algae such as *Tolypothrix tenuis, Calothrix brevissima*, *Anabaena sp.* and *Anabaenopsis sp.* are powerful nitrogen fixers, and that in paddy fields inoculated with *Tolypothrix tenuis* the yield was increased by 15 to 20 per cent. Dr. Desikachary has taken great pains in compiling this monograph which contains exhaustive information on blue-green algae found in India as well as in the neighbouring countries. I hope that this monograph will be of considerable use to students as well as to research workers who are interested in the study of this important group of algae.

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VICE-PRESIDENT
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NEW DELHI
APRIL 21, 1959

# PREFACE

It was in 1940 that I started my study of the blue-green algae under the guidance of Professor M. O. P. Iyengar in the University Botany Laboratory, Madras. Since then this fascinating group of algae has continuously occupied my attention. The need for a book on Cyanophyta dealing with the species recorded from India and the neighbouring countries was felt for a long time. An opportunity for writing a book of this type came when at a meeting held on 21st May 1956, Dr. Randhawa, Vice-President of the Indian Council of Agricultural Research, entrusted me with the task of preparing a monograph on the morphology and systematics of blue-green algae. This publication is in fulfilment of that assignment. The text includes species recorded from India and adjoining countries. Part I of the present work deals with the structure of the cell and its contents, types of branching, and methods of vegetative reproduction and propagation. This is followed by a consideration of the Classification and Phylogeny. Part II deals with the Systematics of the Indian Cyanophyta. In the description of genera and species I have generally followed the type description. Only essential references for each species have been cited. Synonyms, except when they were first synonymised have generally been omitted. But when an alga has been reported in the past under a binomial which is now a synonym such synonyms have been given under the valid binomials. The description is followed by information on habitat and distribution in the region. Key to the genera and species generally follow those given in the works of Bornet and Flahault, Gomont, Lemmermann, and Geitler. The illustrations have been re-drawn for this publication from original sources or else they are original illustrations drawn by me or, in a few cases, by Prof. Iyengar and his collaborators.

Many changes have recently been suggested in the Taxonomy of the blue-green algae based on cultures and study of type material. Changes have also been suggested because of lack of distinguishing characters in many cases between the different taxa and/or the presence of intermediate characters or forms, or an account of extreme variation obtaining within a species. Whilst a great deal can be said in favour of the arguments adduced by different workers, it is generally felt that each material has to be studied both from the point of view of cultural variations of genera and species, identified by established systematics and correlated with variations in the field before assessing the impact of such studies on taxonomy.

I am very thankful to Professors M. O. P. Iyengar, T. S. Sadasivan and G. F. Papenfuss for their kind suggestions and advice in the course of the present work. I must record my indebtedness to Professor Geitler whose monumental work in the Rabenhorst's series and subsequent publications on blue-green algae form the starting point of study for every modern student of Myxophyceae. Much of the material presented here has been derived from these as well as works of other algologists such as Fritsch, Frémy, Lemmermann, Forti, Borzi, Bornet and Flahault, Thuret and Gomont. I am also indebted for suggestions and criticisms to Dr. M. S. Randhawa under whose inspiration the compilation of the present series of monographs has been undertaken.

The present work may not reach the standards expected of similar contributions. Realising the shortcomings in my effort, I humbly conclude with the following quotation of the words of Linnaeus: " If you detect any mistakes of mine, I rely on your superior knowledge to excuse them; for who has ever avoided errors in the wide-extended field of Nature? Who is furnished with a sufficient stock of observations? I shall be thankful for your friendly corrections, I have done what I could myself."

UNIVERSITY BOTANY LABORATORY,
MADRAS
5TH OCTOBER 1958

T. V. DESIKACHARY

# CONTENTS

Page
FOREWORD .. .. .. .. .. .. .. .. .. .. .. v
PREFACE .. .. .. .. .. .. .. .. .. .. .. .. vii

## PART I — GENERAL PART

STRUCTURE .. .. .. .. .. .. .. .. .. .. 3
  RANGE OF VEGETATIVE CONSTRUCTION .. .. .. .. 3
  CELL .. .. .. .. .. .. .. .. .. .. .. 6
    CHROMATOPLASM .. .. .. .. .. .. .. .. 6
      PIGMENTATION .. .. .. .. .. .. .. .. 8
      COMPLEMENTARY CHROMATIC ADAPTATION .. .. .. 10
    CENTROPLASM .. .. .. .. .. .. .. .. .. 11
    CELL-WALL .. .. .. .. .. .. .. .. .. .. 13
    PIT-CONNECTIONS .. .. .. .. .. .. .. .. 15
  PHOTOSYNTHESIS AND NITROGEN FIXATION .. .. .. 15
  GAS-VACUOLES .. .. .. .. .. .. .. .. .. 16
  MOVEMENTS .. .. .. .. .. .. .. .. .. .. 19
  MUCILAGE ENVELOPES AND SHEATHS .. .. .. .. .. 21
  HETEROCYSTS .. .. .. .. .. .. .. .. .. 25
    STRUCTURE .. .. .. .. .. .. .. .. .. .. 26
    FORMATION .. .. .. .. .. .. .. .. .. 27
    GERMINATION .. .. .. .. .. .. .. .. .. 29
    FUNCTION .. .. .. .. .. .. .. .. .. .. 30
  BRANCHING .. .. .. .. .. .. .. .. .. .. 32
    TRUE BRANCHING .. .. .. .. .. .. .. .. 32
      LATERAL BRANCHING .. .. .. .. .. .. .. 33
      DICHOTOMOUS BRANCHING .. .. .. .. .. .. 33
      REVERSE 'V'-SHAPED BRANCHING .. .. .. .. 33
    FALSE BRANCHING .. .. . .. .. .. .. .. 37

VEGETATIVE PROPAGATION AND REPRODUCTION .. .. 37
  HORMOGONES .. .. .. .. .. .. .. .. .. 37
  PSEUDOHORMOGONIA (HORMOCYSTS) .. .. .. .. .. 39
  ENDOSPORES .. .. .. .. .. .. . .. .. .. 41
  NANNOCYTES .. .. .. .. .. .. .. .. .. .. 43
  EXOSPORES .. .. .. .. .. .. .. .. .. .. 43
  PLANOCOCCI .. .. .. .. .. .. .. .. .. .. 43
  SPORES (AKINETES) .. .. .. .. .. .. .. .. 43

BIOLOGY .. .. .. .. .. .. .. .. .. .. .. .. 45
  PLANKTONIC FORMS AND WATER-BLOOMS .. .. .. .. 45
    MARINE AND OTHER SALT-WATER FORMS .. .. .. .. 48
  EPILITHIC AND ENDOLITHIC FORMS .. .. .. .. .. 50

BIOLOGY—*Contd.*

*Page*
AEGAGROPHILOUS FORMS .. .. .. .. .. .. 51
THERMAL ALGAE .. .. .. .. .. .. .. .. 51
COLD WATER FORMS .. .. .. .. .. .. .. 53
. SYMBIOSIS AND OTHER ASSOCIATIONS OF BLUE-GREEN ALGAE .. .. .. .. .. .. .. .. .. .. .. 53
SAPROPELIC AND COLOURLESS FORMS .. .. .. .. 57
PARASITIC BLUE-GREENS .. .. .. .. .. .. .. 57
PATHOLOGY OF BLUE-GREEN ALGAE .. .. .. .. 58

FOSSIL BLUE-GREEN ALGAE .. .. .. . .. .. .. 58

CLASSIFICATION AND PHYLOGENY .. .. .. .. .. 60

PART II — SYSTEMATIC PART .. .. .. .. .. .. .. 71
INTRODUCTION TO THE INDIAN BLUE-GREEN ALGAE .. 73
DESCRIPTIONS OF INDIAN SPECIES .. .. .. .. .. 77
LATIN DIAGNOSES OF NEW TAXA .. .. .. .. .. 617
RECENT ADDITIONS TO THE INDIAN FLORA .. .. .. 619

BIBLIOGRAPHY TO THE GENERAL PART .. .. .. .. 623

BIBLIOGRAPHY TO INDIAN BLUE-GREEN ALGAE . . 653

INDEX TO THE GENERAL PART .. .. .. .. .. .. 661

INDEX TO GENERA, SPECIES, ETC. .. .. .. .. . 669

# CYANOPHYTA

## PART I
## GENERAL PART

# CYANOPHYTA

The division Cyanophyta includes a large number of Algae which are characterized by a low state of cell organization. The cells lack the well defined nucleus that is met with in the other algae. Cell division is by division of the protoplast by an ingrowth of the septum. These organisms are characterised generally by a blue-green coloration of the cell, the chief pigments being Chlorophyll *a*, Carotenes, Xanthophylls, *c*-Phycocyanin and *c*-Phycoerythrin. The product of photosynthesis is glycogen.

These organisms lack flagellated reproductive bodies and there is a total lack of sexual reproduction.

Some regard these Cyanophycean Algae by their relatively simple cell and body structure may well illustrate the conception of a cell structure which imply differentiated regions of a colloidal system in which special processes have become localised and tend to remain fixed.

## STRUCTURE

### I. RANGE OF VEGETATIVE CONSTRUCTION.

With the absence of any motile flagellated members the blue-green algae may be said to be made of two broad morphological categories of thallus organization, (*i*) non-filamentous forms or coccoid and palmellate forms and (*ii*) filamentous forms.

### 1. NON-FILAMENTOUS FORMS.

The non-filamentous forms are mainly coccoid forms which are either single cells (Pl. 1, figs. 13–14) or grouped in palmelloid colonies (Pl. 1, fig. 22). The coccoid forms have different shapes, spherical, cylindrical, fusiform etc. Cell division (and multiplication) may be in one, two or three directions. In some the daughter cells separate away from each other but in many others they remain, for a shorter or longer period, united or attached to each other leading to the formation of a colony made up of cells of different generations. These cells may be enveloped by one or more diffluent or firm mucilaginous envelopes, the daughter cells of the same generation generally being surrounded by a common envelope. These colonies are either microscopic (Pl. 1, fig. 10), or may become large and macroscopic. Often the cells of the colony may not all have any distinct arrangement. But in genera such as *Merismopedia* (Pl. 1, fig. 25), *Holopedia* etc., the cells of the colony have a definite pattern of arrangement. In *Merismopedia* it is tabular and in *Eucapsis* it is cubical (Pl. 1, figs. 19, 20). In *Coelosphaerium* and *Gomphosphaeria* (Pl. 1, fig. 22) the cells are arranged in a layer along the rim of the spherical hollow colony, and the cells are often connected at the centre through a much branched system of mucilaginous stalks reminding one of *Dictyosphaerium*. In *Cyanostylon* (Pl. 1, fig. 12) the secretion of mucilage is unilateral and the cells are placed terminally on cylindrical mucilaginous stalk-like structures. In *Cyanodictyon* (Pl. 1, fig. 23) the thallus is spherical or flat and reticulate. The colonies of *Microcystis* vary from simple linear or elongate ones to large reticulate or clathrate colonies. A pseudofilamentous condition is seen in the Entophysalidaceae and in *Johannesbaptistia* the colony is long and cylindrical with generally a single series of cells and with cell division in only one plane which is transverse (Pl. 32, figs. 14–19).

*Chamaesiphon* represents a series of forms in which the alga is at first unicellular and attached with a differentiation of base and apex. In some species, e.g., *C. fuscus* (Pl. 10, figs. 1–3) the exospores do not get fully liberated but stay at the apex of the pseudovagina and develop into new individuals. Thus a dendroid colony is formed.

*Pleurocapsa* and *Hyella* represent a series of forms which have a heterotrichous organization very similar to that found in the most advanced of the blue-green algae, the Stigonematales, but lack the trichomatous organization and the hormogones so characteristic of the Stigonematales.

## 2. FILAMENTOUS FORMS.

The simplest filamentous condition is seen in *Oscillatoria* (Pl. 1, fig. 1) which is made up of a long series of cells placed one over the other to form a " trichome ". In *Arthrospira* and *Spirulina* the trichome is more or less permanently spirally coiled. The trichomes often secrete mucilaginous material of varying consistency but in forms like *Lyngbya* (Pl. 1, fig. 21) a distinct, firm tube-like mucilaginous sheath is formed. The term " filament " is applied to denote the trichome and the sheath together. These forms are either straight or in some the tips may be somewhat bent, or twisted. The sheath may be homogeneous throughout or may be lamellated or striated, the lamellation being either obviously parallel or divergent at various degrees from the trichome. In both *Oscillatoria* and *Lyngbya* all the cells of the trichomes are uniform or " homocystous ", while in many others the trichome has at one or both ends or is interrupted at more or less regular intervals by special thick-walled cells, the " heterocysts." These latter forms are called ' heterocystous forms ' (Pl. 5, figs. 7, 8, 12, 15). The trichomes are either unbranched as in *Oscillatoria* and *Lyngbya* or may be branched as in *Westiella* (Pl. 8, fig. 14), *Hapalosiphon* etc. Besides this type of branching, in forms like *Scytonema* (Pl. 5, fig. 17), *Tolypothrix* (Pl. 5, fig. 15), *Plectonema* etc., there are what are known as false branches. This false branching may be visualised as long hormogones or fragments of trichome which germinate or develop *in situ*, with the ends piercing and growing out of the sheath of the parent filament. The trichome in *Rivularia, Gloeotrichia* (Pl. 1, fig. 28), *Calothrix* etc., ends in a long hair whose cylindrical cells

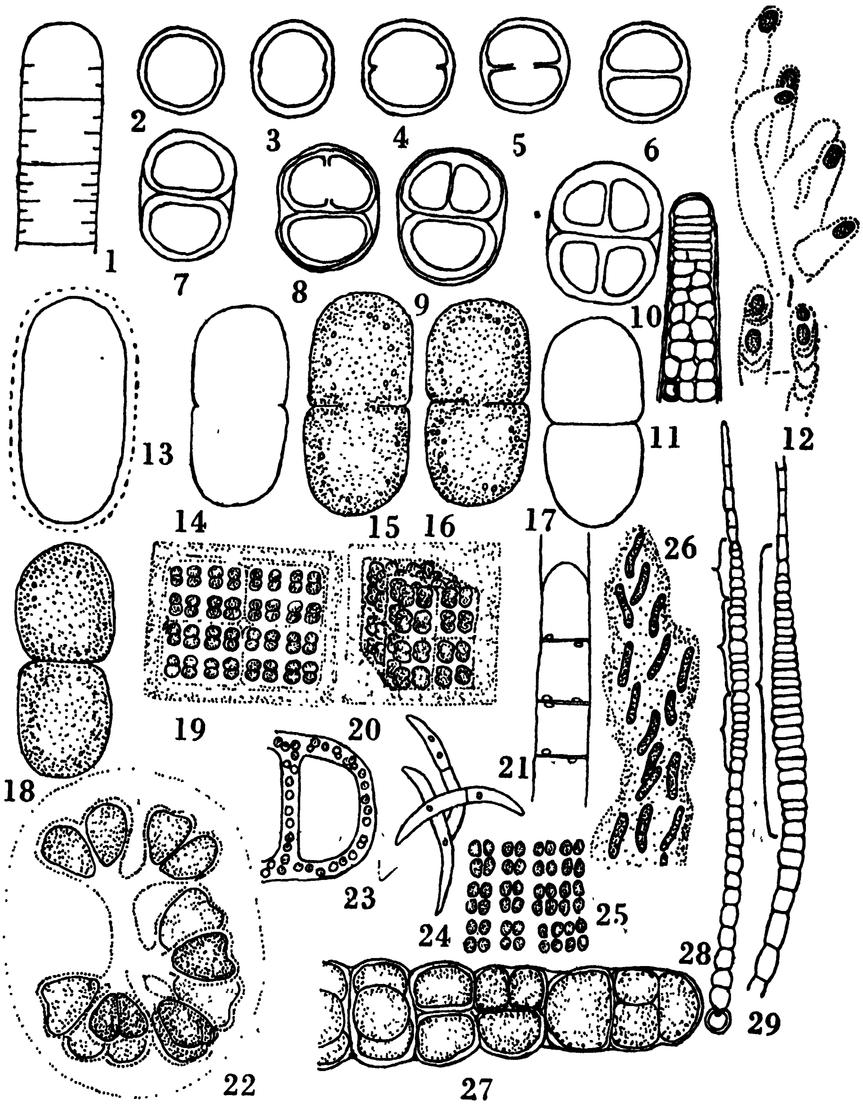


PLATE 1, Figs. 1–29.

1. *Oscillatoria borneti* Zukal, trichome showing successive transverse division (after Geitler); 2–10. *Chroococcus turgidus* Näg., stages in the cell division and colony formation followed in the living condition (after Geitler); 11. *Stigonema mamillosum* (Lyngb.) Ag., showing the apical cell (after Geitler); 12. *Cyanostylon cylindrocellulare* Geitler et Ruttner (after Geitler and Ruttner); 13–18. *Synechococcus major* Schröter, successive stages of cell division followed in a living condition (after Geitler); 19–20. *Eucapsis alpina* Clements et Shantz (after Clements and Shantz); 21. *Lyngbya margaretheana* Schmid (after Schmid); 22. *Gomphosphaeria aponina* Kütz. var. *cordiformis* Wolle (after Smith); 23. *Cyanodictyon reticulatum* (Lemm.) Geitler (after Lemmermann); 24. *Dactylococcopsis raphidioides* Hansg. (after Fritsch); 25. *Merismopedia punctata* Meyen, colony (after Smith); 26. *Gloeothece linearis* Näg. (after West and West); 27. *Siphononema polonicum* Geitler, showing a portion of the stigonemoid stage (after Geitler); 28. *Gloeotrichia pisum* Thur., and 29. *Rivularia polyotis* (Ag.) Born. et Flah. showing intercalary meristematic zone situated below the hair (after Schwendener).

are vacuolated to varying degrees. In many filamentous forms cell-division and growth are generally diffuse or spread over the entire length of the trichome. In *Scytonema* it is nearly restricted to the apical region although intercalary growth is also common. In *Stigonema* there is a distinct apical cell (Pl. 1, fig. 11). In the piliferous forms such as *Rivularia,* division and growth are generally restricted to a series of cells below the hair, the intercalary meristematic region (Pl. 1, figs. 28, 29). The most advanced forms have a heterotrichous condition or habit (e.g. many Stigonematales). The most common mode of reproduction in the filamentous forms is by the formation of small or short pieces of trichomes, the hormogones, which become specially cut off by the death of an intercalary cell or cells or by the secretion of biconcave discs of intercellular substances (Pl. 7, figs. 19–24).

## CELL

The cyanophycean protoplast is clearly divisible into two parts: (1) a peripheral pigmented region, ' chromatoplasm ', and (2) a central colorless region, the ' centroplasm ' (or the ' central body ') (Schmitz, 1879; Fischer, A., 1897) (Pl. 2, figs. 17, 20, 21). These two regions are generally clearly demarcated. But such a demarcation may also be totally absent and the centroplasm may extend into the chromatoplasm (Massart, 1901; Phillips, 1904; Zacharias, 1907; Swellengrebel, 1910; Acton, 1914; Geitler, 1936).

### 1. CHROMATOPLASM.

The protoplast is alveolar in structure (Pl. 2, fig. 17) and the alveoli consist of a thick viscous or gel-like substance (Baumgartel, 1920; Hof and Frémy, 1933). Geitler (1936), however, thinks that the cytoplasm is homogeneous. It has considerable amount of imbibed water and cytoplasm sticks to the wall. The contents do not collapse when centrifuged. The osmotic pressure of the cell is low (Schmid, 1923; see also Hansgirg, 1883; Krenner, 1925). For plasmolysis strong solutions are needed, the contents do not plasmolyse into a ball and the cells are capable of quick de-plasmolysis. Plasmolysis has been noted by many workers (Brand, 1903b; Fischer, 1891; cf. Borzi, 1886) but is considered to be incomplete (Prat, 1923b), and de-plasmolysis occurs after some time (Fischer, 1891; Prat, 1921; Hof and Frémy, 1933). Schmid (1923) determined the concentrations needed for effecting contraction of the protoplasm in an *Oscillatoria* sp., saccharose 1 per cent, $KNO_3$ 0·85 per cent, NaCl 0·017 per cent, urea 0·5 per cent. De-plasmolysis occurred in all cases except in the case of saccharose. Some truly saline forms can withstand without plasmolysis 3–5 molar strengths of NaCl and even in these cases de-plasmolysis was observed (Hof and Frémy, 1933). This property of the protoplast is attributed to the presence of a strong adhesion between the protoplasm and the cell wall.

Mitochondria are absent (Guilliermond, 1915; 1926; Schmid, 1918).

There is no visible protoplasmic streaming (cf. however, Gaidukov, 1910; Schmid, 1918).

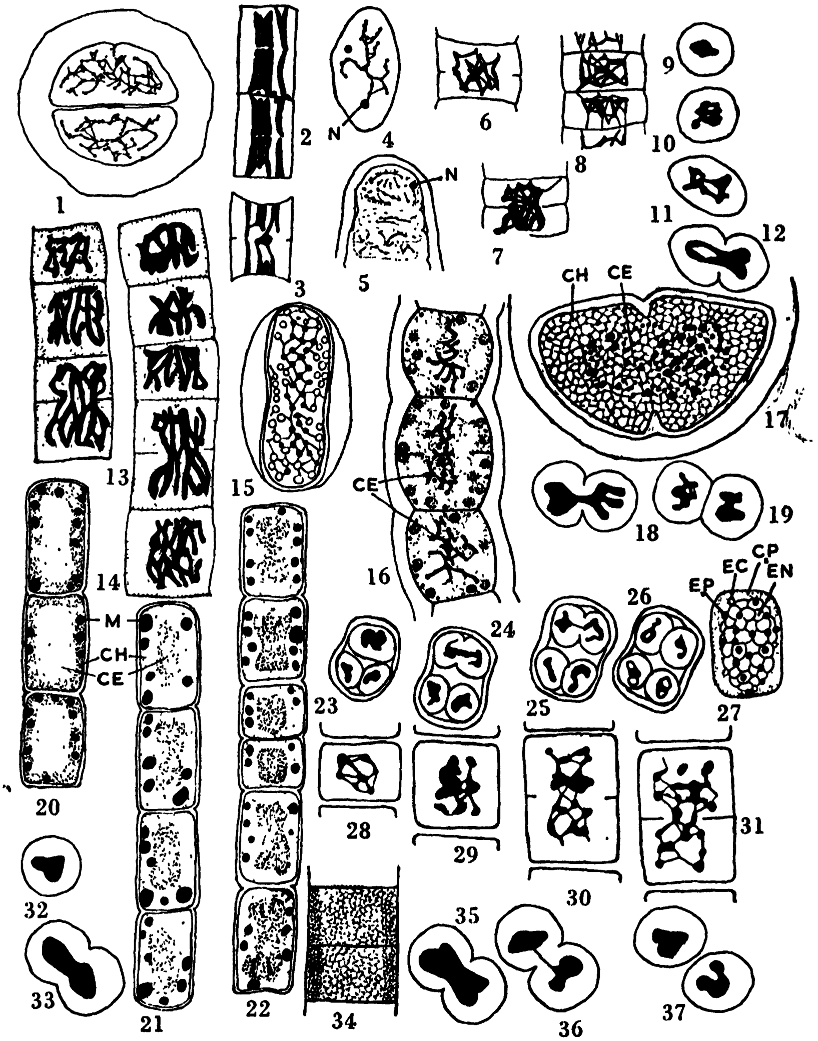


PLATE 2, Figs. 1–37.

1, 4, 5. *Stigonema mamillosum* (Lyngb.) Ag. 1. transverse section just behind the apex; 4, a pericentral cell and 5, longitudinal section showing chromatin and nucleoli-like bodies (N) (after Spearing); 2, 3. *Oscillatoria* sp., showing chromatin and cell division (after Spearing); 6, 7, 8. *Oscillatoria tenuis* Ag., cell division (after Spearing); 9–12, 18, 19. *Synechococcus cedrorum* Sauv., cell division (after Cassell and Hutchinson); 13, 14. *Phormidium favosum* (Bory) Gom., cell division (after Guilliermond); 15. *Aphanothece prasina* A. Br., cell structure (after Acton); 16. *Anabaena circinalis* Rabenh., longitudinal section showing structure and division (after Haupt); 17. *Chroococcus turgidus* Näg., cell structure (after Acton); 20–22. *Phormidium retzii* (Ag.) Gom., progressive stages of staining with methylene blue, showing the metachromatin granules, chromatoplasm and the centroplasm (after Guilliermond); 23–26. *Chroococcus* sp., cell division (Cassell and Hutchinson); 27. Schematic representation of a blue-green algal cell showing the types of granular inclusions (after Baumgartel); 28–31. *Phormidium autumnale* (Ag.) Gom., cell division (after Cassell and Hutchinson); 32, 33, 35–37. *Gloeocapsa alpicola* (Lyngb.) Born., cell structure and division (after Cassell and Hutchinson); 34. Normal cells of *Oscillatoria borneti* Zukal (after Geitler). CP, CE = Centroplasm; EN = endoplast; EC = ectoplast; EP = epiplast.; M = Metachromatin; CH = Chromatoplas

Large sap-vacuoles as are known in the other algae, have not been observed. Vacuolisation is preceded by a loss of photosynthetic pigments. Vacuolisation is generally a prelude to death in blue-green algae, and generally takes place in old cells. Small vacuoles begin to appear and these coalesce to form larger ones. Geitler (1921a) describes very clearly the progression of a special type of vacuolisation which converts the whole cell into a network of sap-vacuoles separated by delicate cytoplasmic lamellae (Pl. 2, fig. 34; Pl. 3, figs. 5–7). These cells however continue to divide.

In the chromatoplasm are found large refractive granules, cyanophycin granules, and these are of the nature of reserve food materials. Some suggest these are proteinaceous (Fritsch, 1945). These granules are arranged in certain species on either side of the transverse septa (Pl. 3, fig. 1, 3). These however contain a large proportion of arginine (Fogg, 1951b). According to Baumgartel (1920) there are three kinds of cell-inclusions: (*i*) endoplasts of varying shapes occupying the alveoli of the centroplasm, (*ii*) the epiplasts which are spherical and lie in the cytoplasmic lamellae, and (*iii*) the ectoplasts (cyanophycin granules) located in the peripheral (chromatoplasm) region (Pl. 2, fig. 27).

Metachromatin granules, which are comparable to albuminoid volutin are often reported to occur in the blue-green algae (Meyer, 1904; Kohl, 1905; Zacharias, 1907). These are generally arranged at the periphery of the chromatoplasm (Olive, 1905; Gardner, 1906; Spearing, 1937) (Pl. 2, figs. 20–22).

Fat droplets also occur in the blue-green algae.

**Pigmentation.** The Pigments are generally localised in the chromatoplasm or rarely the whole cell may be pigmented, e.g., *Chroococcus turgidus* (Chodat, 1894; Geitler, 1924; cf. Buell, 1938).

The pigments are uniformly distributed in the chromatoplasm and the pigmented region is clearly distinguishable (Hieronymus, 1892; Palla, 1893; cf. Baumgartel, 1920; Spearing, 1937). The exact mode of distribution of pigment is not known: (*i*) the pigments are uniformly distributed in the chromatoplasm (Guilliermond, 1906; 1926; Olive, 1905) or located, (*ii*) in minute vesicles (Macallum, 1899; Wager, 1903; Baumgartel, 1920; Haupt, 1923; Lloyd, 1923), (*iii*) or in granules (Hieronymus, 1892; Palla, 1893). These granules are sometimes regarded as chromatophores or cyanoplasts (Hegler, 1901; Kohl, 1905). Recently Calvin and Lynch (1953) have reported grana-like structures in *Synechococcus cedrorum* in which the pigments are located.

Hieronymus (1892), Phillips (1904), Olive (1904), Meyer (1904) and Fisher (1905) consider the blue-green algae as having a peculiar type of chromatophore. To a similar conclusion arrive Niklowitz and Drews (1956) based on electron microscope studies. The chromatoplasm has a lamellated structure. The lamellae are thickened granularly and these granular thickenings are considered by them as homologous with the primary grana of the higher plants.

Shinke and Ueda (1956) studied *Oscillatoria princeps* with the electron microscope and Shinke himself studied in addition *O. limosa* and *Scytonema crispum*. According to them the chromatoplasm is made of parallel lamellae (*see* also Niklowitz and Drew, 1956). These are not stained by neutral red and hence these lamellae according to these authors cannot be considered as endoplasmic reticulum. These authors suggest these organelles are equivalent to the chloroplasts and chromatophores because assimilation products are found in these lamellae but these do not form definite chromatophores.

Chlorophyll is known to occur in the blue-green algae (Cohn, 1867). It has been identified to be Chlorophyll *a*. Chlorophyll *b* is absent (Kylin, 1937; Seybold and Egle, 1937). Inmann (1940), however, reports the presence of Chlorophyll *b* in small quantities in some thermal algae, but it is doubted as being due to the presence of green algal contaminants. This chlorophyll may be formed in them (Étard and Bouilhac, 1898; Brunnthaler, 1909; Boresch, 1910; Schindler, 1913).

Carotenes have been reported by a number of workers (Fischer, 1897; Tammes, 1900; Kylin, 1912, 1927; Tischer, 1938, 1939; Heilbron, 1946). According to Kylin (1927, 1937, 1939) the blue-green algae have four carotenoid pigments, carotene, calorhodin *a* and *b* and myxorhodin. Myoxanthin (?) (Phycoxanthin of Kraus and Millardet, 1869; Sorby, 1875; Aphanin and Calorhodin *a*) is a carotenoid with a single absorption band (Carter *et al.*, 1939; Heilbron *et al.*, 1935). Flavicin is another carotenoid reported from *Aphanizomenon flos-aquae* (Tischer, 1938) and may be identical with mutatochrome (Karrer and Jucker, 1950).

The commonest xanothphyll is called Myxoxanthophyll (also Myxorhodin, Phycoxanthin or Aphanizophyll) (*see* Heilbron and Lythgoe, 1936; Carter *et al.*, 1939; Kylin, 1939; Tischer, 1938, 1939; Heilbron, 1942; Karrer and Rutschmann, 1946). Lutein has been reported by Heilbron (1946) though Goodwin (1957b) has failed to demonstrate or detect it in any of the other blue-green algae investigated by him and Zeaxanthin and Oscillaxanthin are reported in *Oscillatoria rubescens* by Karrer and Rutschmann (1944).

Goodwin (1952, 1957a, 1957b) has investigated the carotenoid pigments in a number of blue-green algae and has summarized the present position. According to him blue-greens have three major carotenoids, β Carotene, Echinenone and Myxoxanthophyll. Aphanin reported from *Aphanizomenon flos-aquae* (Tischer, 1938, 1939) and Myxoxanthin (Heilbron and Lythgoe, 1936) are probably identical with echinenone (4-keto-β-carotene; *see* Goodwin and Taha, 1951; Goodwin, 1957b). Myxoxanthophyll and Aphanizoxanthophyll are considered to be identical (Heilbron, 1942; Goodwin, 1957b). The two other known carotenoids are Oscillaxanthin and Aphanicin (Karrer and Rutschmann, 1944; also Tischer, 1938). β-carotene is present in all the blue-greens examined. Echinenone is not so far known from any other group of plants and is considered to be unique (Fogg, 1956; Goodwin, 1957b).

Geitler (1956a, 1956b) describes two species of *Oscillatoria, O. carotinosa* and *O. pseudoacutissima* in which the carotenoid is localised in the form of prominent granules on either side of the septa just as in some other species the gas-vacuoles are localised along the septa.

Many blue pigments have been reported. A few of these at least are considered to be varying mixtures of Phycocyanin and Phycoerythrin (Boresch, 1921; Kylin, 1937). The commonly occurring pigment is *C*-Phycocyanin. (Svedburg and Katsurai, 1929; Kylin, 1937). This has an absortion maxima at about 615 mμ (*see* Strain, 1951). This is mainly responsible for the color of the alga. Haxo *et al.* (1954) has reported a new Phycocyanin, *P*-Phycocyanin, with an absorption maxima 650 mμ. *C*-Phycocyanin is readily soluble in water with traces of alkali or of a neutral salt and is readily extracted in chloroform water (Kohl, 1903). These pigments show fluorescence (Lloyd, 1923).

Phycoerythrin is often reported especially in deep water forms and the exact nature of the red pigment is not known (Bocat, 1908; Teoderesco, 1920). Wille (1922; cf. Danilov, 1922; Kylin, 1937) suggests that this red pigment is the same as the Rhodophycean one. But recent researches have shown that this is not so. *C*-Phycoerythrin has an absorption peak at about 560 mμ and is quite distinct. A two peaked Phycoerythrin with absorption maxima at 542 and 566 mμ has been reported by Haxo *et al.* (1954) from *Phormidium ectocarpi* and *Ph. fragile*.

Both Phycocyanin and Phycoerythrin may be present or only either of them and by their mixture in varying proportions the characteristic coloration of the particular alga is derived (*see* Kylin, 1912, 1937; Boresch, 1921d; Haxo *et al.*, 1955). These pigments are easily decomposed in strong light and Phycocyanin does so more easily (Harder, 1917b; Boresch, 1921b; Sargent, 1934; Delarge, 1937).

**Complementary chromatic adaptation.** A number of blue-green algae have a capacity to change their color in relation to the wave length (color) of the incident light. This change in color is often described as complementary chromatic adaptation or ' Gaidukov phenomenon '. Gaidukov (1902, 1903b, 1906, 1923; *see* also Engelmann, 1883) was the first to give a scientific explanation of this color change. This phenomenon is very common in the Cyanophyceae, though instances of this phenomenon are not lacking in the Rhodophyceae.

Members of the Oscillatoriaceae and the Nostocaceae exhibit this phenomenon very commonly and it is generally restricted to certain species (for the different species *see* Klingstedt, 1909; Zuelzer, 1911; Pringsheim, 1913; Schindler, 1913; Boresch, 1919, 1921c; Harder, 1922, 1923; Susski, 1929; Sargent, 1934). Gaidukov (1902) investigated *Oscillatoria sancta.* It developed green shades in red light, blue-green in yellow-brown, red in green, and brownish yellow in blue light. Similarly (Gaidukov, 1906, 1923) *Phormidium* *tenue* exposed to a spectrum developed an yellowish color in the green violet regions and a blue-green color in the rest. The color changes are possible only in such species as have both Phycocyanin and Phycoerythrin (Boresch, 1921c; Kylin, 1937).

Various explanations have been given for the color changes and severe criticisms have been made by different authors on experimental techniques (*see* Boresch, 1921). A precise idea of the causes is yet to be arrived at.

(*i*) Boresch (1919, 1921c) found some sort of a relation between the quantity of the different pigments and the wave length of the incident light, while Dangeard (1911) observed changes only in red and infra-red rays in *Lyngbya versicolor* (*see* also Gaidukov, 1906, 1923).

Deep water forms develop a red or violet coloration (Godward, 1937). *Trichodesmium erythreaum* is reported to be primarily a bottom living species which occasionally comes up and forms a water bloom (Feldmann, 1932). The coloration is developed by this alga by exposure to normal light and some even suggest it is inherited.

(*ii*) Nadson (1908) suggests that the change is due to the intensity of light (*see* also Sargent, 1934). Some even doubt the presence of any adaptation (Sauvageau, 1908; Harder, 1922; Oltmanns, 1923) and feel that change in color is due to exposure to different light intensities (for light intensity and decomposition of red and blue pigments *see* Harder, 1917; Boresch, 1921; Sargent, 1934; Delarge, 1937).

(*iii*) Other workers suggest an entirely physiological explanation for such color changes. Yellow colors predominate in cultures deficient in Nitrogen (Nitrogen chlorosis of Boresch), Phosphorus and Iron (*see* Boresch, 1910, 1913, 1919; 1921a; Magnus and Schindler, 1912; Schindler, 1913; Pringsheim, 1913; Maertens, 1914; Steinecke, 1923; Sargent, 1934; Börgstrom, 1935; Korner, 1936; Fogg, 1952; Pintner and Provasoli, 1958). Manganese and Chromium sulphate can cause a reversal of this condition (Boresch, 1924). Organisms growing in strong light show increase in the uptake of mineral nutrients leading to an yellowing (Schindler, 1913).

## 2. CENTROPLASM.

The blue-green algal cell lacks the nucleus that the other algae have (Chodat, 1896). But all workers are agreed that whatever nuclear material is there is present in the centroplasm (Pl. 2, figs. 13, 14, 16, 17) and gives a positive or negative reaction (Poljansky and Petruschewsky, 1929; Spearing, 1937; Cassell, 1952). Many consider the centroplasm as the equivalent of a nucleus (Wager, 1903; Meyer, 1904; Fischer, 1905; Gardner, 1906; Guilliermond, 1906; Brown, 1911; Baumgartel, 1920; Geitler, 1922; Haupt, 1923; Prat, 1925a; Delaporte, 1939; 1940; 1949; Cassell and Hutchinson, 1954; *see* also Rothmaler, 1948; Bringmann, 1950; 1952; Herbst, 1953, 1954; Zastrow, 1953). The central body lacks a nuclear membrane and the nucleoli

(Pl. 2, figs. 1, 17). Spearing (1937) however, reports the presence of a membrane around the central body in *Oscillatoria splendida* Grev. (cf. Kohl, 1903). Acton (1914) and Guilliermond (1906, 1925) think that the nuclear material is regularly or irregularly localised at the points of junction of the protoplasmic reticulum (or the alveolar central body) (Pl. 2, figs. 15, 17). The nuclear material may be said to be generally aggregated into three types (*i*) loose net-like organization, (*ii*) rod-like elements oriented parallel to the longitudinal axis of the cell and (*iii*) a very much condensed organization of various shapes. These bodies stain deeply with nuclear stains and seem to be very similar to chromatin (Dehorne, 1920; Poljansky and Petruschewsky, 1929; Petter, 1934; Goncalves de Cunha, 1935; Spearing, 1937; Bringmann, 1951; Delaporte, 1939–40; Bold, 1951). Various names such as 'open nucleus' (Baumgartel, 1920) and 'incipient nucleus' (West, G. S. 1916) are also given to the central body.

In *Stigonema mamillosum* (Lyngb.) Ag., Spearing (1937) reports the presence of nucleoli like bodies (cf. Lee, 1927) and he even saw its connections with the chromatin reticulum (*see* also Bütschili, 1898; Wille, 1883; Zacharias, 1889, 1900; Meyer, 1904; Guilliermond, 1906, 1926; Moureau, 1919; Spratt, 1911) (Pl. 2, figs. 4, 5).

Krieg (1954) studied the centroplasm with the help of acridin orange as a fluorochrome. The nuclear equivalents are rod-shaped and spiral structures with or without a relationship to each other of the two and to the trichome axis. He does not confirm the presence of any isotropic localisation of nuclear equivalents and metachromatin granules (*see* Bringmann, 1952). Shinke and Ueda (1956) who investigated the central body in *Oscillatoria princeps* with the help of an electron microscope described what the authors call as 'chromonemata' or 'chromosomes' as dispersed throughout the protoplast, and these do not constitute a definite nucleus. These chromonemata according to them are made up of (*i*) a thin limiting membrane, (*ii*) a homogeneous chromonemata matrix and (*iii*) many fine threads. These fine threads run nearly perpendicular to the longitudinal axis of chromonemata and are parallel more or less at regular intervals.

Poljansky and Petruschewsky (1929), Yamaha and Suematsu (1938), Hillary (1939), Drawert (1949) and Bringmann (1950) have reported positive feulgen reaction in species of *Oscillatoria, Spirulina, Lyngbya, Tolypothrix, Gloeotrichia* while negative feulgen reaction has been reported by Kiesel and Doinikowa (1937), Herbst (1953, 1954), Shinke and Ueda (1956) and Ueda (1956) in some species of *Aphanothece, Oscillatoria, Pseudanabaena, Nostoc* and *Tolypothrix*. Bringmann (1950) has observed positive reaction in *Oscillatoria* treated with lanthanum acetate before hydrolysis. DNA one of the main constituents of the cell nucleus has however been reported to be present in species which are feulgen negative. The negative feulgen reaction is attributed to the presence of certain protein fractions which inhibit the development of the feulgen reaction of DNA and is also partly due to the fact that the purine to pyrimidine ratio is less than 1·00 (Shinke *et al.*, 1957).

Metachromatin is often reported in the centroplasm (Kohl, 1905; Zacharias, 1907; Poljansky and Petruschewsky, 1929; Guilliermond, 1933; Fritsch, 1945; Bringmann, 1952; Krieg, 1954). Metachromatin is absent in cells grown on phosphorus deficient medium (Zuelzer, 1911; Prat, 1925a) as also in young recently divided cells (Elenkin and Danilov, 1916; Poljansky and Petruschewsky, 1929; *see* also Kohl, 1903). It is considered identical with volutin by some (Meyer, 1904).

Centroplasm has been regarded as a region filled with reserve substances (Geitler, 1922; Meyer, 1904; Prat, 1925a). Fischer (1905) compares these granules as reserve food materials and is of the nature of *anabaenin.* The presence of carbohydrates has not been definitely proved. Glycogen compounds are definitely known to occur in the centroplasm.

Alexeieff (1924) considers the central body as a chondriome while Dangeard (1927) considers it to be vacuome.

Cell-division is by the ingrowth of a septum from the periphery and the gradual and consequent division of the chromatoplasm. The centroplasm roughly divides into two equal parts and is amitotic (Pl. 2, figs. 2, 3, 9–14, 18, 19, 23–26, 28–33, 35, 36). All accounts of a mitosis, chromosomes and a spindle are discredited (*see* however, Baumgartel, 1920; Brown, 1911; Kohl, 1903; Lee, 1927; Olive, 1905; Phillips, 1904; Poljansky and Petruschewsky, 1929).

## 3. CELL-WALL.

The wall of the blue-green algal cell consists of two layers (Fritsch, 1905; Lemmermann, 1910; Spratt, 1911). The two layers are concentric in unicellular forms, a thin inner layer or investment and a thick outer gelatinous layer or the cell sheath (Pl. 3, fig. 10). In the filamentous forms the cell sheath forms a continuous cylinder outside (Fritsch, 1905; Krenner, 1925) or may be interrupted at the crosswalls (Geitler, 1921; Bharadwaja, 1933) (Pl. 3, figs. 8, 11). The septa consist of only the inner investment (Pl. 3, fig. 8).

The inner investment is in close contact with the cytoplasm and is probably only a slightly modified plasma membrane.

The cell sheath gives a pectic reaction and the inner investment gives a certain amount of cellulose reaction (Kylin, 1943). The presence of a large amount of pectin shrouds the cellulose reaction (Kylin, 1946). The pectin occurs in the cell-walls as Ca & Mg salts of an acid. The acid is constituted as an ethereal sulphate which by hydrolysis gives a monosaccharide, galactose. Payen (1938) has also shown that arabinose, glucose, mannose and galactose are present. Chitin is absent (Mameli, 1920; Wester, 1909).

Correns (1897) and Kolkwitz (1897) think the wall is net-like. Krenner (1925) and Ullrich (1926) think it is homogeneous. Kolkwitz (1897), Phillips

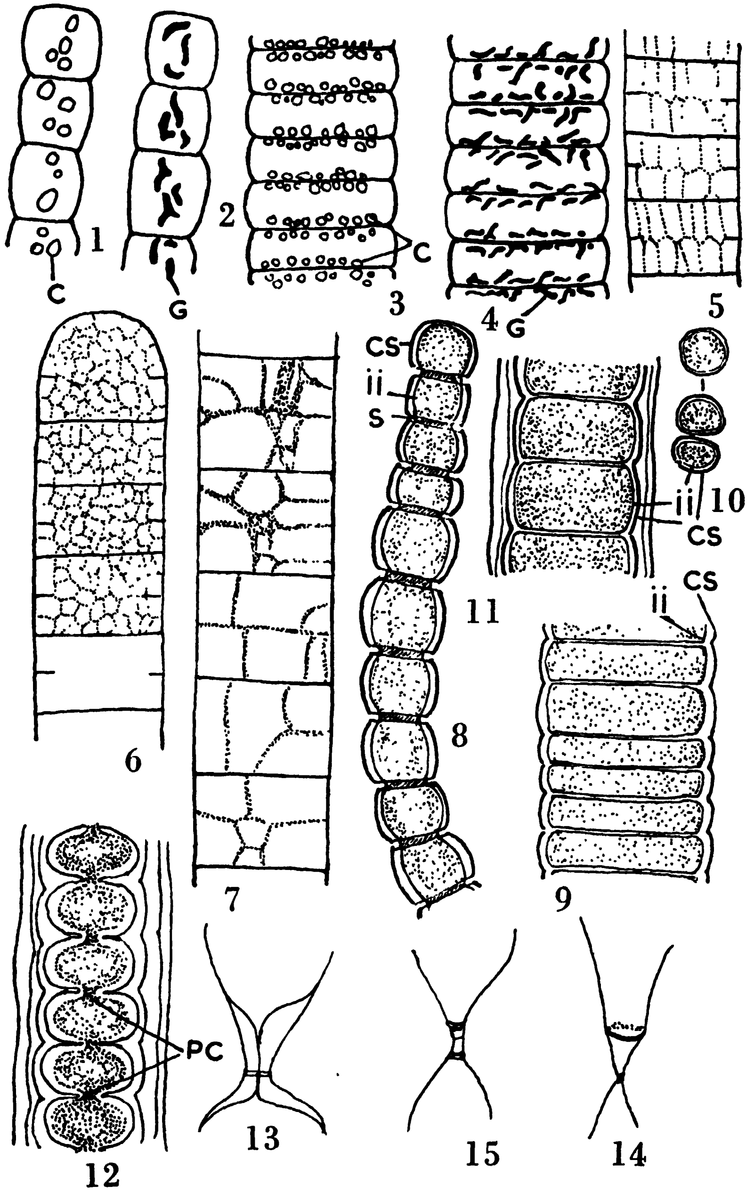


PLATE 3, Figs. 1–15.

1, 2. *Nostoc linckia* (Roth) Born. et Flah., and 3, 4. *Phormidium ambiguum* Gom., var. *major* Lemm., parts of pairs of trichomes showing the relative distribution of cyanophycin granules (C) and gas vacuoles (G) (after Canabaeus); 5, 6, 7. Stages in vacuole formation in *Oscillatoria borneti*. 6, early and 5 and 7 successively later stages. Normal condition is shown in Plate 2, Fig. 34 (after Geitler); 8–11. 8, Part of a trichome of *Anabaena* .sp., 9. *Oscillatoria* sp., 10. *Aphanocapsa sescianensis* Frémy, and 11. *Tolypothrix* sp., showing the cell membranes (8, 11, after Fritsch, 9 after Spearing, and 10 after Frémy), (*ii* = inner investment; CS = cell-sheath; S = septa): 12. *Stigonema ocellatum* (Dillw.) Thur., part of a filament showing pit connections (PC) (after West); 13. Pit connections in *Tolypothrix lanata* Wartm. (after Spearing); 14, 15. Pit connections in *Stigonema ocellatum* (Dillw.) Thur. (after Spearing).

disintegrated. Later (1929) Klebahn showed that these vacuoles disappeared in a special vacuum. It is suggested that the vacuole may be bounded by an impermeable membrane making an escape of the gas difficult and such a conception, it appears, is made possible when one takes into consideration the special gel-like consistency of the blue green protoplasm (*see* Fritsch, 1945, p. 773).

The nature of the enclosed gas is not known though it is often suggested that it might be nitrogen or a nitrogenous compound (amine) (Klebahn, 1895, 1922, 1929; Lauterborn, 1916). Klebahn suggests that the vacuole membrane may be permeable to oxygen which may also be present (or stored) in these vacuoles and becomes available for respiration.

(2) A diminution of gas-vacuoles has been observed in planktonic species when kept in dark, and their re-appearance when exposed to strong light, led to a suggestion that these may act as light screens (Lemmermann, 1910; also Troitskaja, 1921).

(3) Molisch (1903; *see* also Lauterborn, 1915) suggested that these gas-vacuoles contain a viscous substance of a low specific gravity; but here again that the gas-vacuoles disappear under pressure is against it.

(4) Fischer (1905) considered these as an optical effect due to the anisotrophy of a carbohydrate, anabaenin. Their disappearance in organic solvents is attributed to a breakdown of anabaenin during cytolysis. A similar optical phenomenon is however not recorded in all the blue-green algae.

The formation of these gas-vacuoles have been studied by Kolkwitz (1925) and Canabaeus (1929). Many blue-green algae inhabiting anaerobic habitats such as sapropel and bottom muds have gas-vacuoles in large numbers (Utermöhl, 1925). Bethge (1935) recorded a correlation between the appearance of a species of *Chroococcus* with gas-vacuoles as a plankton and the existence of anaerobic conditions. Canabaeus (1929) produced artificially gas-vacuoles by keeping material in solutions of sodium chloride or iron sulphate in a stream of hydrogen. But the algae did not survive later and began to degenerate. According to her the gas-vacuoles occupy the same position in the protoplast as the cyanophycin granules do and may be the fermentation products of the latter. Kolkwitz (1928) suggests these fermentation products remain imprisoned within the protoplast.

The frequent presence of gas-vacuoles in the algae which form water blooms has given rise to the suggestion that the gas-vacuoles may serve the function of floatation (Strodtmann, 1895; Klebahn, 1895, Molisch, 1903; cf. Brand, 1901, Fischer, 1905). On germination, the water bloom algae begin as bottom dwellers, develop gas-vacuoles and then rise to the surface (*see* van Goor, 1925; Wesenburg-Lund, 1904; Wislough, 1912; Bethge, 1935; Feldmann, 1932; cf. Brand, 1901).

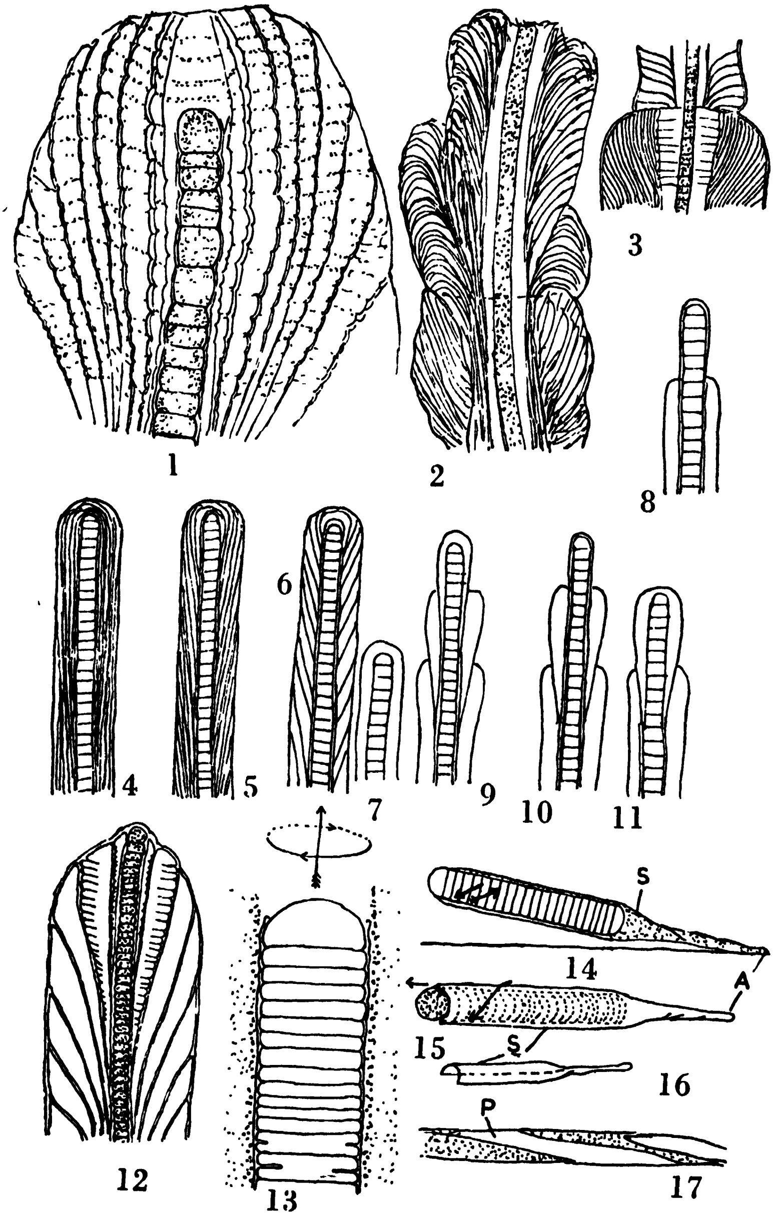


PLATE 4, Figs. 1–17.

1–3, 12. *Petalonema alatum* Berk., structure of the sheath (1, 2, after Geitler; 3, 12, after Correns); 4–6. Types of lamellation of the sheath (after Bharadwaja); 7–11. Formation of successive layers of sheath (after Bharadwaja); 13. *Oscillatoria limosa* (Roth) Ag., ( = *Oscillaria fröhlichii*) in optical longitudinal section showing the direction of movement and rotation and the secretion of mucilage (after Krenner); 14–17. Diagrammatic representation of an *Oscillatoria* showing the direction of movement and mucilage secretion (after Niklitschek), 14, optical longitudinal section showing the trichome, the envelope (S) and the point of attachment (A) of the latter, 15, surface of the same, 16, mucilage envelope only shown, and 17, mucilage threads of *Oscillatoria sancta* (Kütz.) Gom., showing the elongate gaps (P).

## IV MOVEMENTS

Trichomes of only a few of the genera of Myxophyceae exhibit various types of movements, while many filamentous forms still have this capacity though restricted to reproductive bodies such as hormogones. While the trichomatous forms exhibit rapid movements, unicellular forms show only slow movements. Among the trichomatous forms the following genera may be mentioned: *Oscillatoria, Trichodesmium, Spirulina, Arthrospira, Microcoleus, Anabaena,* (Castle, 1926, cf. Smith, 1951), *Aphanizomenon* (Ahlborn, 1895), and *Cylindrospermum* (Geitler, 1932; Harder, 1918). The following cocoid forms have also been reported as showing movements: *Synechococcus* (Perfiliev, 1915), *Gloeothece linearis* (Kongisser, 1932), *Merismopedia punctata* (Niklitschek, 1934), *Holopedia* (Lund, 1942), *Eucapsis alpina* (Lund, 1950), *Chroococcus turgidus* (Lund, 1950), *Coelosphaerium, Microcystis* spp., and *Aphanothece microscopica* (*see* Lund, 1950). In general species living at one time or other on the bottom deposits show motility (Corti, 1774; Meyer, 1893; Schwendener, 1894; de Bary, 1863; Brand, 1903b; Phillips, 1904). Burkholder (1934) gives a very useful review of these movements in the Cyanophyceae.

These movements are one of creeping or gliding in the direction of the longitudinal axis backwards and forwards unaccompanied or accompanied in some species (*Oscillatoria* spp., *Spirulina* spp., and *Arthrospira* spp.) by a clockwise or anticlockwise rotation (*see* Correns, 1897; Crozier and Federighi, 1924; Hansgirg, 1883; Kolkwitz, 1896, 1897; Schmid, 1921, Lanz, 1940). In *Spirulina* the rotation is in the direction of coiling. A slow waving of the terminal portion is reported in *Anabaena* (Castle, 1924). Such a waving of the terminal portion and an axial movement is common in the Oscillatoriaceae. The mode of progression is simple and linear in *Nostoc* and *Anabaena* while in *Oscillatoria* it appears to be curved (Schmid, 1921). Reversal of the direction of movement is also known in *Oscillatoria.*

Various theories have been put forward as to how these movements are caused:—

(*i*) *Secretion theory*: An actual streaming of the outer mucus as evidenced by the movement of adhering foreign particles, it is suggested by some, propels the filament, in much the same manner as in diatoms (Siebold, 1849; Schultze, 1865). A protoplasmic streaming of the cell contents is reported by Gaidukov (1910) and Schmid (1918) and this is said to be related to the movement through the secretion of mucilage. Fechner (1915; *see* also Harder, 1918) suggests that a radial swelling of the mucilage takes place and this helps to squeeze the filament forward. Schmid (1918) entirely rejects this theory, while Burkholder (1934, p. 445) thinks that this theory might possibly explain the movement in the cylindrical forms but may not be applicable to other forms. Prell (1921) suggests that the movement of the filament is due to the secretion pressure of mucilaginous strands through spirally arranged pores in the entire length of the filaments. The direction of the rotation in a screw-like manner is determined by the spiral arrangement of two crossing series of pores. The presence of these pores has not been conclusively proved. Recently, however, based on electron microscope studies a number of workers have reported the presence of pores in the longitudinal and transverse walls (Metzner, 1936; Schulz, 1955; Niklowitz and Drews, 1956; Shinke and Ueda, 1956; Drawert and Metzner, 1956).

Secretion of mucilage during movement by trichomes in forms like *Oscillatoria* has been often reported. This mucilage is cylindrical with one end often attached (Correns, 1897; Hansgirg, 1884; Krenner, 1925; Schmid, 1921; *see* also Fechner, 1915; Schmid, 1921; Niklitschek, 1934; Phillips, 1904; Coupin, 1922). It is sometimes " U " shaped in section (Niklitschek, 1934). The mucilaginous piece has laterally many elongate gaps (Pl. 4, fig. 17) representing temporary cessation of secretion by some cells. The trichome is said to move within this cylindrical mucilaginous piece (Niklitschek, 1934), much as the trichomes of *Lyngbya* and *Phormidium* do in their sheath (Pl. 4, figs. 14–17). This secretion of mucilage has been held to be responsible for the movement (Fechner, 1915; Harder, 1918; Prell, 1921; Schmid, 1918, 1921, 1923; Lauterborn, 1896; Schröder, 1902).

(*ii*) Many Phycologists think that the movement is caused by rhythmic longitudinal waves, caused by alternate contraction and expansion, traversing the entire length of the trichome (Phillips, 1904; *see* also Cohn, 1807; Migula, 1897). Schmid (1918, 1930), Crozier and Federighi (1924) and Ullrich (1926, 1929) have given valuable support to the view. These longitudinal waves are no doubt facilitated by the extensibility of the cell membrane and also the osmotic changes. Ullrich has observed no direct correlation between the velocity of the peristaltic waves and the speed of the organism.

(*iii*) Hansgirg (1883, 1887) attributed the movement to diosmotic changes resulting from a turgor gradient all through the filament. This gradient causes the movement and a change in the gradient due to external conditions results in a reversion of the movement. Though osmotic properties are known to be not uniform throughout the filament, the existence of a definite gradient has not been shown. Changes in surface tension brought about by osmotic exchange between the organism and the environment has been thought to influence the movement (Coupin, 1923; *see* also Hansgirg, 1883).

The rate of movement varies with the species and a maximum rate of 2·5 μ per second has been reported (Burkholder, 1934, p. 440; cf. also Borzi, 1878a, p. 244; Brand, 1903, p. 60; Correns, 1897, p. 148; Weber, 1933, p. 408; Glickhorn, 1921; Crozier and Federighi, 1924; Castle, 1926). Borzi (1878b) reports that hormogones of *Isocystis* move with exceptional rapidity, and those of *Symploca* move very slowly (Schmid, 1918, p. 331). Brand's (1903) diagrammatic representation of the direction and mode of progression of the hormogones of *Phormidium* sp., is given in Pl. 13, fig. 1.

An increase in illumination is accompanied by an increase in the rate of movement. Similarly a doubling of the speed is recorded for every 10°C rise within the range of 6–30°C (Burkholder, 1934; Nienburg, 1916; Pieper, 1913; Schmid, 1918; Harder, 1918). The nature of this response to temperature is not known though it is considered to be in accordance with Arrhenius Law of temperature influence on irreversible chemical reactions (Crozier and Federighi, 1924; Navez, 1928; Burkholder, 1934, p. 451).

The Cyanophycean filaments and their hormogones are positively phototactic (Famintzin, 1867; Bornet and Thuret, 1876; *see* also Borzi, 1886). Though light is not essential for movement (Schmid, 1921) the filaments move more rapidly in light than in the darkness (Hansgirg, 1883; Phillips, 1904; Pieper, 1913; Harder, 1920). The relationship between movement and light intensity vary with the different species (cf. Burkholder, 1934; Pieper, 1913, 1915). Harder (1917) used differential positive phototactic response to secure pure cultures from the hormogones of species of *Nostoc* and *Anabaena.*

There are instances of negative phototactic response also. *Oscillatoria angusta* and *O. splendida* are negatively phototactic (Burkholder, 1934; Famintzin, 1867; Schmid, 1918, 1923; Troitzkaja, 1921). Nienburg (1916) observed that a change from light to dark caused reversal in *Oscillatoria,* while a change from dark to light had no effect on the direction of the movement. A similar phototactic response is also reported in the hormogones in *Nostoc* (Harder, 1918) while Weber (1932) denies its presence in *Calothrix.*

Response to chemical stimuli has been investigated by Schmid (1923, p. 3), Fechner (1915), Pringsheim (1913) and Schindler (1913). Fechner (1915) reported a negative chemotactic response to acids. Schmid (1923) has reported that acids have a lethal effect. Burkholder (1933) observed that the range of pH 6·4–9·5 was most favourable and pH outside these limits have an inhibitory effect on the movement of *Oscillatoria formosa.*

The rate of movement is proportional to the osmotic pressure of the alga and is inversely proportional to the diameter (Correns, 1897; *see* also Krenner, 1925; and Burkholder, 1934). There appears to be no relation between the rate of movement and the length (Crozier and Federighi, 1924; Castle, 1926). Krenner (1925), however, states that there is a minimum length below which movements do not occur. This statement does not appear to be entirely applicable to all blue-greens, especially now that even unicellular blue-green algae are definitely known to show movement, though it is possible that longer filaments may show faster movements (*see* Crozier, and Stier, 1926). Even filamentous forms such as *Oscillatoria* and *Lyngbya* are known to form hormogones of a single cell which are motile.

## V. MUCILAGE ENVELOPES AND SHEATHS

All blue-green algae secrete mucilage. But they differ in the amount of mucilage secreted, the consistence of the mucilage, whether it is homogeneous or lamellated and whether is colored or hyaline. These characteristics in most cases appear dependent on the environmental conditions (Brunnthaler, 1909;

Brand, 1900; Novcek, 1934; Ercegovic, 1925, 1932; Hollerbach, 1924; Itzigsohn, 1854; Jaag, 1940). Especially the coccoid members show a great variation under different experimental conditions such as illumination. Desiccation results in a contraction of the gelatinous material which often becomes colored.

The Chroococcales resemble very much the Chlorococcales. Individual cells have often a distinct sheath and in genera such as *Chroococcus* and *Gloeocapsa,* where the cells of different generations are held together in distinct order, sheaths of the different generations can be easily distinguished as surrounding sister cells or cells of one and the same generation or their progeny. In some genera the mucilage is generally recognizable only after careful staining.

Many genera develop a common colonial mucilage. The colonial mucilage is formed by swelling up of the individual envelopes by imbibition. Correns (1889) found an increase of the sheath by imbibition up to as much as 20 times. The superficial layers of mucilage of some algae, (eg., *Nostoc* spp., and some Scytonemas) develop a firm exterior which is said to contain cutin (Gomont, 1888).

Most filamentous members develop a firm sheath which is often lamellated. The lamellation is described generally as either parallel or divergent (Pl. 4, figs. 4–6). A few genera, however, have a very thin sheath without any perceptible lamellation. In some *Nostoc* spp., the individual sheaths are not generally evident, though the peripheral filaments may have a well-defined often contrastingly pigmented sheath. So also in some species of *Anabaena* (including *Anabaenothrix* Ghose and Randhawa), *Wollea* etc. In *Oscillatoria* the trichome does not have a discernible sheath, but it becomes evident on staining (Fritsch, 1945, p. 829; Krenner, 1925; Fechner, 1915; Niklitschek, 1934).

The exact method of the secretion of mucilage is not known. Fritsch (1905, 1945, p. 793) and Mühldorf (1938b) consider the gelatinous envelopes of the coccoid and the filamentous members to be homologous and are excreted through the inner investment and the layer last secreted functions as the cell-sheath, or the outer investment of the vegetative cell. Geitler (1925b, 1936) distinguishes the envelopes of the Chroococcales from those of the filamentous members. In the former they arise by the modification of the cell-membranes. In the latter the gelatinous material is said to be excreted through the membrane. In this Geitler obviously follows the mode of secretion of mucilage in the green algae. Heterocysts however, do not secrete any mucilage around themselves.

Schröder (1902), Perfiliev (1915) and Leitgeb (1869) have reported a radial fibrillar structure in the mucilage of *Coelosphaerium* and *Synechococcus*; similar structure has also been reported in the Nostocaceae (Schröder, 1902; Hansgirg, 1888; Klebs, 1886). These suggest a possible secretion of the mucilage through pores. Schmid (1921) describes fine pores in the longitudinal walls of *Oscillatoria* and so does Perfiliev in *Synechococcus aerugineus,* though Ullrich

(1926) was not able to find it. Electron microscope studies have revealed that the sheath is made up of reticulately arranged fibrils (*see* Bringmann, 1951; Frey-Wyssling and Stecher, 1954; Metzner, 1955; Niklowitz and Drews, 1956).

The correlation between growth and the formation of sheath has been studied by Correns (1889) (Pl. 4, figs. 1–3, 12), Bharadwaja (1933b) and Jaag (1935). According to Bharadwaja the growing trichome ruptures through the apical sheath and secretes a new sheath which generally extends back to some distance. Each new lamella formed inside pushes the older lamellae to the outside generally diverging away from the trichome at the upper ends. This process is repeated periodically, the interval depending upon the periodicity in growth (Pl. 4, figs. 7–11). During active growth the lamellae successively formed are relatively long and appear parallel (Pl. 4, fig. 4) while during slow growth the lamellae are relatively short and are distinctly divergent (Pl. 4, figs. 5, 6). The sheath is thus formed by the apposition of successive layers excreted at the surface of the trichome. Growth by intussusception appears to take place in the intercalary portion during intercalary division (*see* Fritsch, 1945, p. 793, 795). Bharadwaja's account essentially rests on a study of the different species with apical growth, and does not take into account a number of forms where the growth is not markedly terminal but is either diffused or intercalary. A study of sheath formation in living material is also called for (Fritsch, 1945, p. 793). ✓

The mucilage envelopes are stained by ruthenium red and other basic dyes and are regarded as pectic. Pentosans and cellulose have also been recorded (Gomont, 1888; Klein, 1915). Lemaire (1901) has shown the sheath in a number of blue-green algae to be made up of a compound (schizophycose) and an acid (pectic acid) combined with an organic base in *Lyngbya* sp., *Phormidium* sp., *Nostoc* sp., *Hapalosiphon* sp., *Scytonema* spp., *Stigonema* sp., (*see* also Viricux, 1910), or of mixtures of cellulose and schizophycose (*Desmonema, Diplonema, Scytonema, Tolypothrix*). In *Anabaena, Cylindrospermum, Gloeotrichia, Nodularia* and *Nostoc* it is a simple pectinase. According to Krenner (1925) the mucilage secreted by *Oscillatoria limosa* is made of hemicellulose and not pectin (cf. Ullrich, 1929).

The gelatinous envelopes are often colored yellowish, brownish, reddish, violet or bluish. In some aquatic forms, however, they remain hyaline. The pigments are often prominent and darker in the inner layers and less so progressively outwards. Bharadwaja thinks that the pigments originate in the inner layers and gradually extends to the outer layers. These outer layers were originally layers formed in the inside whose portions came to occupy an outer position in the case of divergent stratification or may entirely become external by the gelatinization of the older outer lamellae and a secretion of new inner lamellae in the case of parallel stratification. It is possible that a layer becomes pigmented while lying inside and with its causing to lie external, may undergo gradual gelatinization and a consequent thinning out of or bleaching of the pigmentation. In the colonial forms however the sheaths of the outer filaments

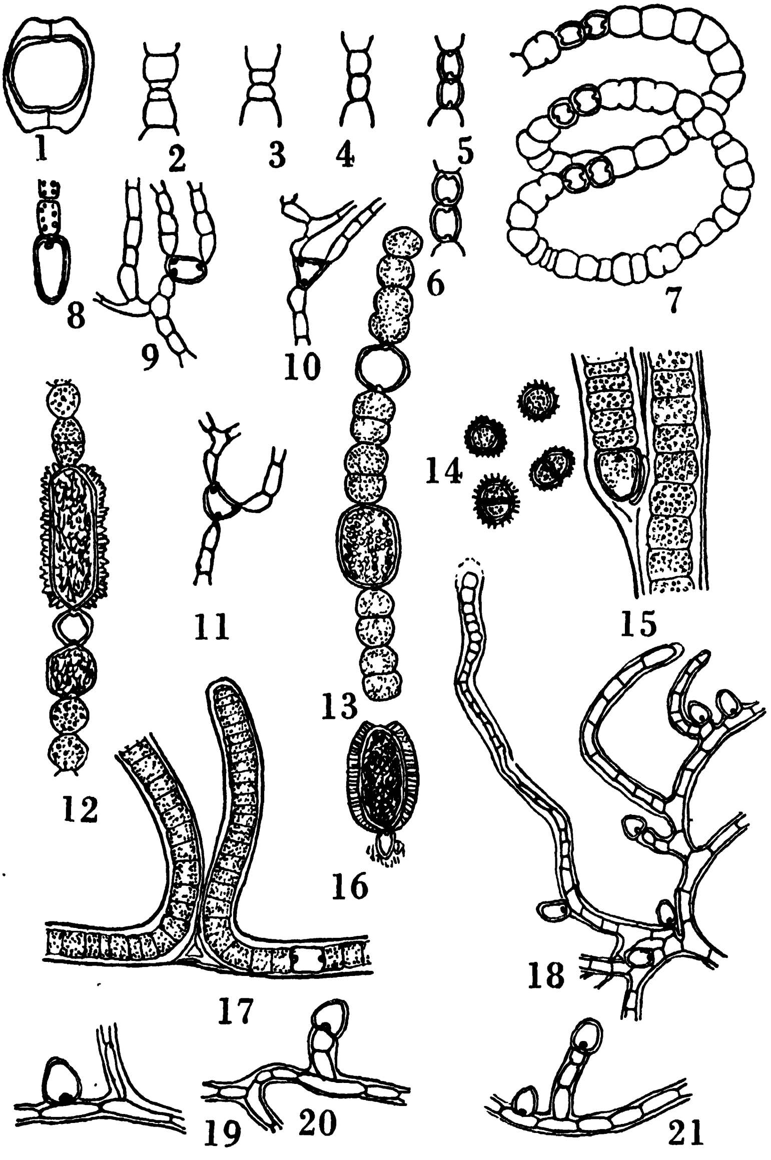


PLATE 5, Figs. 1–21.

1. A heterocyst of *Nostoc commune* Vaucher, showing the wall structure (after Geitler); 2–7. *Anabaenopsis arnoldii* Aptekarj, showing the paired heterocysts and their formation (after Aptekarj); 8. A heterocyst of *Cylindrospermum muscicola* var. *kashmiriensis* (after Bharadwaja); 9–11. *Brachytrichia balani* (Lloyd) Born. et Flah., showing three pored heterocysts (after Iyengar and Desikachary); 12. *Anabaena echinospora* Skuja showing akinetes (after Skuja); 13. *Anabaena affinis* Lemm., showing akinetes (after Smith); 14. *Gloeothece rhodochlamys* Skuja, spores (after Skuja); 15. *Tolypothrix distorta* var. *penicillata* (Ag.) Lemm., showing a false branch and a terminal heterocyst (after Geitler); 16. *Cylindrospermum alatosporum* Fritsch, spores (after Fritsch); 17. *Scytonema arcangelii* Born. et Flah., showing geminate false branches and intercalary heterocysts (after Frémy); 18. *Mastigocoleus testarum* Lagerh., and 19–21, *Nostochopsis lobatus* Wood em. Geitler, showing sessile and pedicellate lateral heterocysts, and intercalary heterocysts (18 after Iyengar and Desikachary, and 19–21 after Desikachary).

are evident and even get pigmented. The pigments probably act as light screens (Lemmermann, 1910).

The pigments from the mucilage envelopes of blue-green algae have been isolated and studied by a few workers. Gloeocapsin and scytonemine have been known for a long time (Jaag and Gemsch, 1940; *see* also Correns, 1889; Nägeli, 1849; Nägeli and Schwendener, 1877). Gloeocapsin is said to be responsible for red and blue color, while scytonemine is responsible for yellow and brown. The exact chemical composition of these is not known though Jaag and Gemsch (1940) deny the presence of any Phycocyanin in gloeocapsin.

Two crystallizable substances, fuscorhodin and fuscochlorin, have been isolated from the sheaths of *Calothrix scopulorum* by Kylin (1927). According to Kylin (1937) scytonemine may be a mixture of the two pigments.

## VI. HETEROCYSTS

Heterocysts are, as the name itself denotes, cells which are easily distinguishable from the rest of the cells by their thick-walls, and by the generally homogeneous and pale yellowish contents.

### 1. OCCURRENCE.

The heterocysts are present in most filamentous blue-greens excepting the Oscillatoriaceae and a few stray genera in the other families. They are very evenly and regularly distributed, and are found situated either in the middle of a filament (intercalary heterocysts) (Pl. 5, figs. 12, 13, 17) or at the ends of the filaments (terminal heterocysts) (Pl. 5, fig. 8). The intercalary heterocysts are often marked out by a tapering of the two neighbouring vegetative cells towards it. Terminal heterocysts are sometimes formed only at the bases of filaments (basal heterocysts) (Pl. 1, fig. 28; Pl. 5, fig. 15) or may terminate very short 1–3 celled lateral branches (pedicellate heterocysts) (Pl. 5, figs. 18, 20, 21). In certain genera these heterocysts are formed on the sides of filaments and remain adpressed to the filament (lateral heterocysts) (Pl. 5, fig. 19). The occurrence of some of these are often restricted to certain families or even to one or two genera only. Intercalary heterocysts are also distinguished by the presence of two pores situated one on either side while the terminal ones (including basal, pedicellate and lateral) have only a single pore situated on the side at which it is attached to the trichome. Thus structurally there are two kinds of heterocysts, one two-pored intercalary heterocysts and the other one-pored terminal heterocysts. However, two-pored intercalary heterocysts may occupy a terminal position after the fragmentation of the trichomes.

Heterocysts generally occur single but rarely two or more may be in series. In one genus *Anabaenopsis* occurrence of paired heterocysts appears to be unique (Pl. 5, fig. 7).

## 2. STRUCTURE.

The wall of the heterocyst is usually thick and two distinct layers can be noticed: (1) an outer thick wall and (2) an inner thin wall or investment (Pl. 5, figs. 1, 8). The two layers are different in their chemical composition. The inner layer is definitely of cellulose and stains with chloro-zinc-iodide (Brand, 1901; Kohl, 1903; Geitler, 1921b; Bharadwaja, 1933; Klein, 1915). But there has been some difference of opinion in the nature of the outer layer which is often somewhat gelatinous. It has been considered to be cellulose by some workers (Hegler, 1901; Klein, 1915) but it does not very often give cellulose reaction (Gomont, 1888; Kohl, 1903; Brand, 1903; Ramanathan, 1938; Fritsch, 1951). Geitler (1921b) is of the opinion that it is pectic but here again pectic stains like Ruthenium red do not seem to be of any great help in staining (Fritsch, 1951; also Bharadwaja, 1933; Ramanathan, 1938). The outer wall is very thick and is highly persistent. Ⓢ

The contents of the heterocysts are generally dense and uniform. Fogg (1951) has observed some sort of a transverse zonation in the contents of the heterocysts in *Anabaena cylindrica* and in a species of *Hapalosiphon*. Such a zonation is not known in any other species. The contents are generally yellowish in color and this is probably due to the disappearance of photosynthetic pigments leaving only the carotenes (Fritsch, 1951, p. 199; 1945, p. 798), which phenomenon is attributed to nitrogen-phosphorus deficiency (Boresch, 1913; Pringsheim, 1913; Maertens, 1914, p. 453). In many, however, the heterocysts retain a vivid blue-green color (Schmidle, 1896; Brand, 1903; Fritsch, 1907; Weber, 1933).

The walls of the heterocysts have one or two pores perforating them. The walls are much thickened around the pores. This thickening, according to Fritsch (1951) is restricted to only the inner investment.

Often at these pores a prominent granule, the polar granule, is seen (Pl. 5, fig. 8; Pl. 6, fig. 20). The polar granules are highly refractive. Kohl (1903) compares it to a flag-like callus. These are considered to be cyanophycin granules by some workers (Palla, 1893; cf. however, Baumgartel, 1920; Geitler, 1921b, p. 231). Fogg (1951), however, thinks these are probably not cyanophycin granules as they are not soluble in dilute acids. He considers these granules are formed by the aggregation of a substance at a time when the connections with the neighbouring cells are blocked or interrupted. According to Geitler (1921) and Baumgartel (1920) these are of the nature of epiplasts of the ordinary cells and have a resistant nucleo-glyco-proteinaceous outer layer and a proteinaceous interior. These poles of the heterocysts abound in material which stain darkly with arginine and feulgen (Fogg, 1951).

Fritsch (1951, p. 187) does not find any granule as such but attributes this granule like appearance to a thickening of and modification of the inner investment at the region of the pore with a substance similar to cyanophycin. But in view of the fact that distinct granules have been observed and figured, both in normal heterocysts and germinating or rejuvenating heterocysts (Geitler, 1921b, 1936; Bharadwaja, 1933a; Desikachary, 1946) Fritsch's observation needs confirmation.

Heterocysts are connected with the neighbouring cells by means of protoplasmic connections which pass through the pores of the heterocysts. These connections and the related pores are developed on one or more sides at which the parent cell was earlier connected to the rest of the trichome. If the original cell has been an intercalary cell then two pores are developed one on either side or only one pore is developed if the original cell is an end cell. Thus commonly only one-pored and two-pored heterocysts are known. Recently, however, Iyengar and Desikachary (1953) have reported in *Brachytrichia balani* a few cases in which heterocysts have developed three pores (Pl. 5, figs. 9–11). These heterocysts are formed by cells which were the branch basal cells. A similar occurrence of three-pored heterocysts has also been reported in *Mastigocladus laminosus* (Venkataraman, 1957). It is through these pores that the heterocysts are said to be in protoplasmic continuity (*see* Geitler, 1936) with the neighbouring cells. Obliteration of one of the pores of an intercalary heterocyst when they become terminal has been reported in *Anabaenopsis* by Ramanathan (1938; cf. Brand, 1903). According to some (*see* Fogg, 1951, p. 30) this connection is merely made up of the inner investment which is now tubular and there is no protoplasmic connection. Mühldorf (1937) also thinks this connection simply represents the extended cell-membrane forming a tubular connection between the heterocyst and the vegetative cell. Fritsch (1951, p. 196), however, thinks there is cytoplasmic continuity or connection.

### 3. FORMATION.

The contents of cells that are to become ultimately the heterocysts become uniform, and paler in color. Then the end walls become rounded. Later the constriction between this developing heterocyst and the neighbouring cells become deeper till at last this cell has a narrow waist-like connection with the neighbouring cells. Next a new wall (inner layer of the heterocyst wall) is formed inside the cell. Very soon polar thickenings develop and the protoplasmic connections become evident. The polar granules are developed later in many cases.

Mostly the heterocysts are developed from recently divided cells. Usually a single cell develops into a heterocyst but rarely both the daughter cells may develop into two heterocysts. Pairs of heterocysts are also seen in *Anabaenopsis* but are formed differently (Miller, 1923; Aptekarj, 1926; Taylor, 1932; Ramanathan, 1938; Fritsch, 1951). In this genus pairs of heterocysts are developed from two neighbouring small daughter cells formed from an unequal division of two neighbouring daughter cells (Pl. 5, figs. 2–6).

The contents of the heterocyst are normal both in the nature of the cytoplasm and the centroplasm (*see* Baumgartel, 1920; Geitler, 1921b).

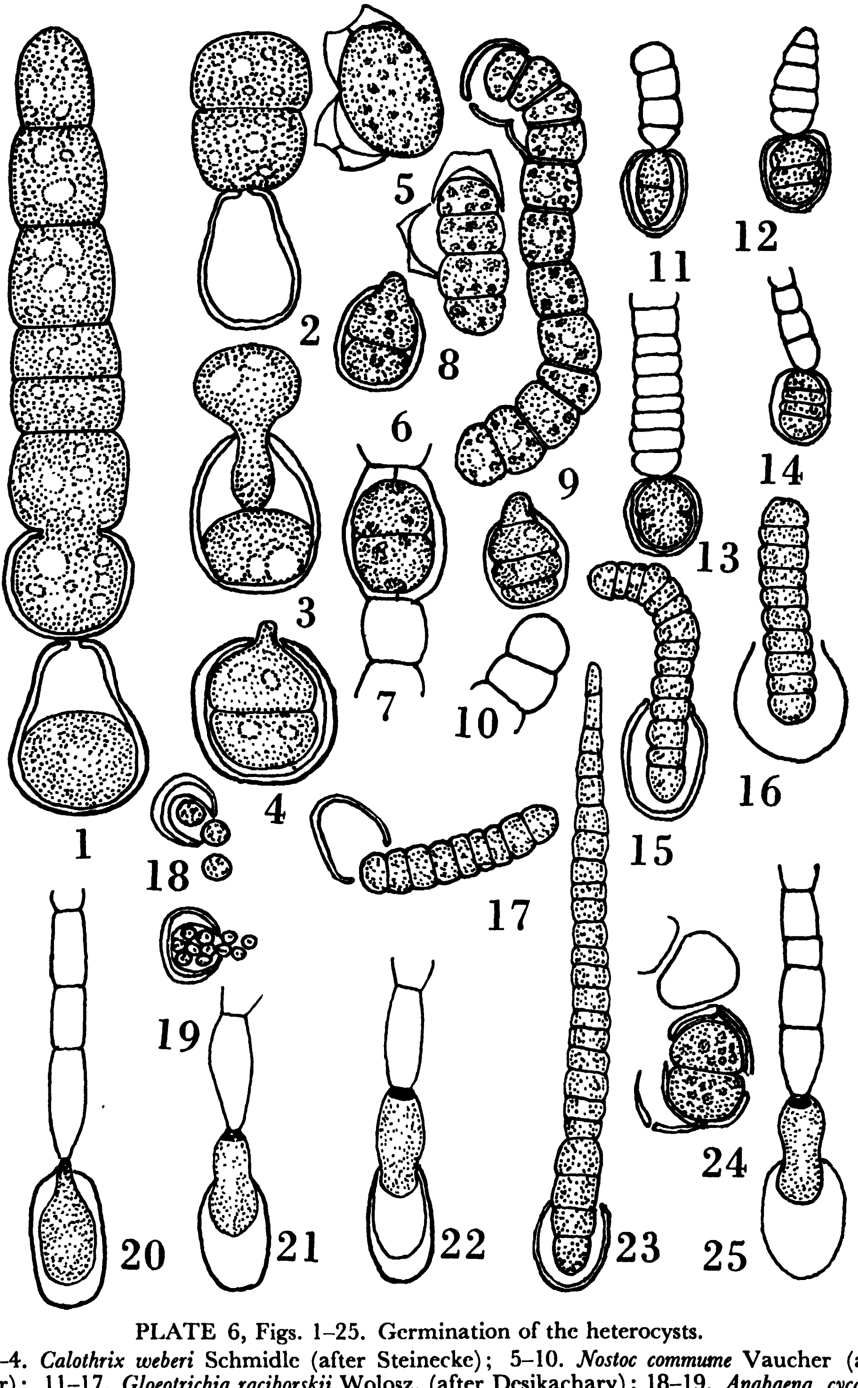


PLATE 6, Figs. 1–25. Germination of the heterocysts.

1–4. *Calothrix weberi* Schmidle (after Steinecke); 5–10. *Nostoc commume* Vaucher (after Geitler); 11–17. *Gloeotrichia raciborskii* Wolosz. (after Desikachary); 18–19. *Anabaena cycadeae* Reinke, endospores (after Spratt); 20–22, 25. Rejuvenation of the contents of the heterocysts in *Gloeotrichia raciborskii* Wolosz. (after Desikachary); 23, 24. *Nostoc linckia* Bornet (after Geitler).

Poljansky and Petruschewsky (1929) and Spearing (1937), did not find any chromatin material in the fully developed heterocyst comparable to the centroplasm of the vegetative cell (*see* also Fogg, 1951, p. 30).

Poljansky and Petruschewsky (1929) and Fogg (1951, p. 29) have both found that the contents exhibit a diffuse and uniform staining with feulgen reagent. But according to Kohl (cited after Geitler, 1921b) these heterocysts are degenerate cells. This latter statement is not compatible with accounts of germination of the contents of fully mature heterocysts (*see* below). But if the heterocysts are really found to be different in its internal organisation from the vegetative cell then the production of normal filaments by the germination of such heterocysts can be possible only if the chromatin material can arise *de novo* as migration is not possible especially as the cells are killed during the experiments leading to germination (*see* Geitler, 1921b), and more so if one is to accept Fogg's (1951) observations on the absence of any protoplasmic connections between the neighbouring cells and the heterocysts (cf. Fritsch, 1951). The other possibility is that the heterocysts take a long time for becoming degenerate and that up to or till a particular stage they retain the capacity to germinate. The slow degeneration and only gradual loss in chromatin material or even migration of the chromatin have not been so far reported and hence the heterocysts must be presumed to be ordinary cells though different from the vegetative cells and are not degenerate.

Canabaeus studied the behaviour of these heterocysts to various nutrients. In cultures with halides such as sodium chloride, potassium chloride, calcium chloride, barium chloride and strontium chloride, sodium bromide and sodium iodide, the heterocysts showed an increase in size and number proportional to the concentration of these salts. She found out the optimum concentrations of sodium chloride above which a reduction in size was observed. With iron, cobalt and nickel there was a reduction in size. $O_2$-deficiency in dark caused an increase in the size of the heterocyst.

Old heterocysts especially in the Scytonemataceae (*see* also Fritsch, 1951, p. 207) get vacuolated (Bharadwaja, 1933) and begin to degenerate. This, however, is not the case in other families. In Rivulariaceae especially many heterocysts can be seen strewn about in the older parts of the mucilaginous colony apparently with the contents intact (Fritsch, 1907, 1945, 1951; Weber, 1932; *see* also Steinecke, 1932). No cases have been reported of a vacuolated heterocyst either germinating or recovering and it appears as though the setting in of the vacuolation starts a process of ultimate degeneration.

## 4. GERMINATION.

Geitler (1921b), Hollerbach (1923), Canabaeus (1929), Steinecke (1932), Desikachary (1946) and Fogg (1949) have described the germination of the heterocyst in a number of blue-green algae. The genera in which germination has been observed are *Anabaena, Nostoc* (Pl. 6, figs. 5–10, 24), *Tolypothrix, Calothrix* (Pl. 6, figs. 1–4), *Brachytrichia, Gloeotrichia* (Pl. 6, figs. 11–16) and

*Rivularia*. But in only five species the germlings have been observed to develop into fully grown filaments, *Nostoc commune* (Geitler, 1921b), *Tolypothrix elenkinii* (Hollerbach, 1923), *Calothrix weberi* (Steinecke, 1932), and *Gloeotrichia raciborskii* (Desikachary, 1946).

In most cases germination has been observed only in laboratory cultures. Only in a few cases it has been reported from nature. Geitler (1921b) and Desikachary (1946) have observed germination after giving the heterocyst short low-temperature treatments while others have observed it in ordinary cultures. Fogg (1949), however, reports that germination of the heterocysts were observed during first few days of growth in cultures supplied with succinate and in no other cultures.

According to Geitler (1921b) at first a two-celled germling is formed which undergoes further division and forms a four-celled germling (Pl. 6, figs. 6, 7, 10). This germling often comes out of the heterocyst by the rupture of the heterocyst wall at the equatorial region or by the gradual dissolution and widening up of the pore (Pl. 6, figs. 8, 10, 24). This germling after coming out grows into a new filament (Pl. 6, fig. 9).

The stages of germination in *Calothrix weberi* are different from all the others. According to Steinecke (1932) the contents of the heterocyst first divides into two daughter cells by a transverse division (Pl. 6, fig. 4). The upper cell squeezes out of the heterocyst through the pore and later on develops into a new filament (Pl. 6, fig. 3). The lower cell degenerates inside the old heterocyst wall (Pl. 6, fig. 1).

During germination the inner cellulose layer disappears (Geitler, 1921b; Desikachary, 1946) and it is believed that it serves as a reserve cellulose (*see* also Geitler, 1936).

Rejuvenation of the entire contents has been described by Desikachary (1946) in *Gloeotrichia raciborskii* (Pl. 6, figs. 20–22, 25). Brand (1903) has described a similar phenomenon in *Tolypothrix penicillata* Thur. var. *tenuis* Hansg. (Pl. 12, fig. 20).

The heterocysts in *Nostoc commune, N. microscopicum* and *Anabaena cycadeae* have been observed to produce gonidia (endospores) (Brand, 1901; Spratt, 1911) (Pl. 6, figs. 18, 19). These gonidia later develop into new filaments.

### 5. FUNCTION.

For a long time the heterocysts have been considered to serve simple mechanical functions such as affording suitable places for fragmentation (Borzi, 1878; Kirchner, 1900; *see* also Borzi, 1905; Turchini, 1918; and Kohl, 1903). Very recently Serpette (1948) also suggested that the heterocysts serve some important mechanical functions. Fogg (1951, p. 34) suggested that the formation of heterocyst results in the release of material which may be needed to maintain adjacent cells.

Hieronymus (1892), Hegler (1901) and Fritsch (1904) hold the view that the heterocysts are store houses of food material (*see* also Brand, 1901). Fogg (1944) has similarly suggested that the heterocysts are the seat of salt accumulation (*see* however, Fogg, 1951, p. 34). The absence of any large quantity of storage products such as cyanophycin, seems to be against this view. Fogg (1944) also suggests that the formation of heterocysts may be the result of processes very similar to vacuole formation in plants other than the blue-green algae. He goes further to suggest that in the Oscillatoriaceae where the heterocysts are absent, cell division proceeds simultaneously in all the cells of a filament and no one cell is more depleted (*see* Fogg, 1951, p. 34).

Brand (1901), Spratt (1911) and Geitler (1921b) consider the heterocysts as archaic reproductive bodies which have lost their functions. That they were originally spore like bodies is deduced from the occasional germination of their contents. Geitler derives support from Borzi's (1907) observations on *Nostoc insulare* that the heterocyst-forming cells when arrested during development develop instead into spores. Steinecke (1932) observed their germination in 80 per cent of the cases in cultures and hence he suggests that at least in *Calothrix weberi* these heterocysts function as secondary reproductive organs.

Many workers have failed to observe germination and hence consider it as an extremely rare phenomenon. The occurrence of two kinds of spores one largely functionless is not known elsewhere (*see* Fritsch, 1951, p. 208). Further, the extreme regularity in the occurrence of the heterocyst in the heterocystous blue-greens suggests some function yet unknown and algologists have suggested diverse active functions.

Geitler (1936) and Fogg (1944) suggest some sort of connection between frequency of cell division and growth and the heterocysts.

Canabaeus (1929) found a sort of a connection between the formation of gas-vacuoles and heterocysts. She observed that forms which do not normally have gas-vacuoles developed them in cultures and that simultaneously heterocysts became reduced in size and ultimately disappeared. She suggests that the heterocysts are receptacles for an enzyme which is responsible for the appearance of these gas-vacuoles. The presence of an enzyme has not been demonstrated by Canabaeus and her suggestion about the function of the heterocysts has not been generally accepted. Recently, however, Fritsch (1951) derives from her work a sort of a new conception of the function of the heterocyst. The heterocyst secretes a substance which stimulates growth and cell division; with the fall in the concentration of this substance consequent on the distance between the heterocysts becoming greater and greater owing to cell division and growth, new heterocysts are formed. With the setting in of the reproductive period the nature of secretion changes to one that stimulates spore formation. The above suggestion remains for the present a hypothesis.

The relation between the heterocyst and spore formation is evident in a number of genera. In many the spores are restricted to the immediate neighbourhood of the heterocyst, while in others spore formation begins away from the heterocyst. During spore formation many have observed a gradual depletion of the contents of the neighbouring heterocysts and have connected it as denoting a function of supplying food material to the developing spores (*see* Bharadwaja, 1933a, Singh, R. N., 1942). In *Gloeotrichia* spores are formed by the first cell next to the heterocyst. The protoplasmic connection between the spores and subtending heterocyst is seen till the spore is completely formed. As the spore is being formed the contents of the heterocyst gradually gets vacuolated and at last disappears. In many cases the old empty heterocyst gets crushed but still remains attached to the mature spores. In a few cases while the spore is developing, the protoplasmic connection between it and the heterocyst gets snapped and in such cases the spore formation is arrested. It becomes converted into a giant heterocyst or it may degenerate and the next cell becomes a heterocyst. The cell next to the heterocyst becomes a spore. This clearly shows that the heterocyst has some role in spore formation. The heterocysts seem to retain the capacity of reproducing like any other ordinary cell. But the spore formation is known in non-heterocystous forms also and this offers one objection to this conception.

Fritsch's suggestion seems to be worthy of investigation, for spore forming substances. These heterocysts seem to have in them the secretion or formation of a substance promoting spore formation. This substance in the non-heterocystous spore producing forms is produced by the entire trichome and this capacity has become restricted to the heterocyst in the heterocystous forms. There seems to be no other way of explaining this connection between the heterocysts and spores, especially so in cases where the spore-formation takes place away from the heterocyst and still the heterocysts get depleted. This is also supported by the fact that in forms which have only short trichome and which do not form spores as in some of the Rivulariaceae the heterocysts generally retain the contents without degeneration. The vacuolization of the contents of the heterocysts takes place in some species of *Scytonema* without any spore-formation. In this genus the filaments tend to become extremely long both by extensive branching and by false branching. In the older portions of the filament even the ordinary cells show much the same process of degeneration as the heterocysts.

## ✓ VII. BRANCHING

Bornet and Flahault (1885 and 1886) distinguish two types of branching viz., (1) true branching and (2) false branching. Their conception of the two types of branching holds good even today.

### 1. TRUE BRANCHING.

True branching may be subdivided into three types (*a*) lateral branching, (*b*) dichotomous branching and (*c*) reverse V-shaped branching.

**Lateral branching.** A cell in the main trichome divides longitudinally and the outer cell grows out into a branch (Bornet and Flahault, 1886a, p. 382; 1887, p. 51; Geitler, 1936, fig. 51a-d.). The connection between the branch and the main filament is always retained. This type of branching is called lateral branching and occurs in the Stigonematales (Pl. 7, figs. 1–4), *Hapalosiphon* is a very typical example where this type of branching can be easily followed. The branch generally arises from a recently divided cell. Generally one but sometimes both the daughter cells give rise to branches. The branch basal cell does not generally divide any further. Rarely, however, it has been observed that the basal cell of the branch divides, in which case the branch may rest on two cells.

**Dichotomous branching.** In the Loriellaceae, Pulvinulariaceae and in *Colteronema* Copeland (1936) the branching is dichotomous resulting from the vertical division (longitudinal division) of the apical cell (Borzi, 1914–17; Frémy, 1929) (Pl. 7, figs. 5–7). In the Capsosiraceae however, the branching is lateral, but owing to the unequal growth it appears subdichotomous or pseudodichotomous.

In the Nostochopsidaceae branching is true and lateral. In *Mastigocoleus* a slight modification often occurs. Short lateral branches terminate in a heterocyst and their growth is arrested. But soon the cell below the heterocyst becomes active and forms a lateral branch very close to the heterocyst. This lateral branch bends over and grows further. During growth, however, the heterocyst is often pushed to one side and there is a certain amount of straightening up of the branch. This branching appears as a sort of sympodium.

**Mastigocladaceous or reverse 'V'-shaped branching.** The fully developed branch in this type rests on two cells or two short pieces of trichome and appears as resting on the vertex of a reverse 'V'-shaped structure, e.g., *Brachytrichia* and *Mastigocladus*.

Bornet and Thuret (1880), Ercegovic (1929), and Frémy (1936) among others have studied this form of branching. According to Bornet and Thuret (1880) and Ercegovic (1929) the branching is initiated by the lateral protrusion and oblique division of pairs of cells. The two arms continue to divide and as a result a branch surmounts the basal 'V' (Pl. 7, figs. 12–21). Thus according to them the loop is formed first and then one of the two arms forms the branch. Iyengar and Desikachary (1954) have given a different account of the mode of branching (Pl. 7, figs. 27–38). The branching is essentially due to the activity of a single cell of the parent filament. This cell undergoes an oblique division into two cells *A* and *B* and one of the cells, *A*, grows out as a branch. Simultaneously with the beginning of the formation of the branch or shortly afterwards a notch is formed in the main trichome immediately below the branch by a bulge on the lower side of cell *B*. By further bulging the notch becomes a tiny reverse 'V'. By still further growth in size and slight elongation of cell *B* and to a certain extent of the adjoining cell (cell *C*), the reverse 'V'-shaped notch at the base of the branch becomes pronounced. By further elongation of

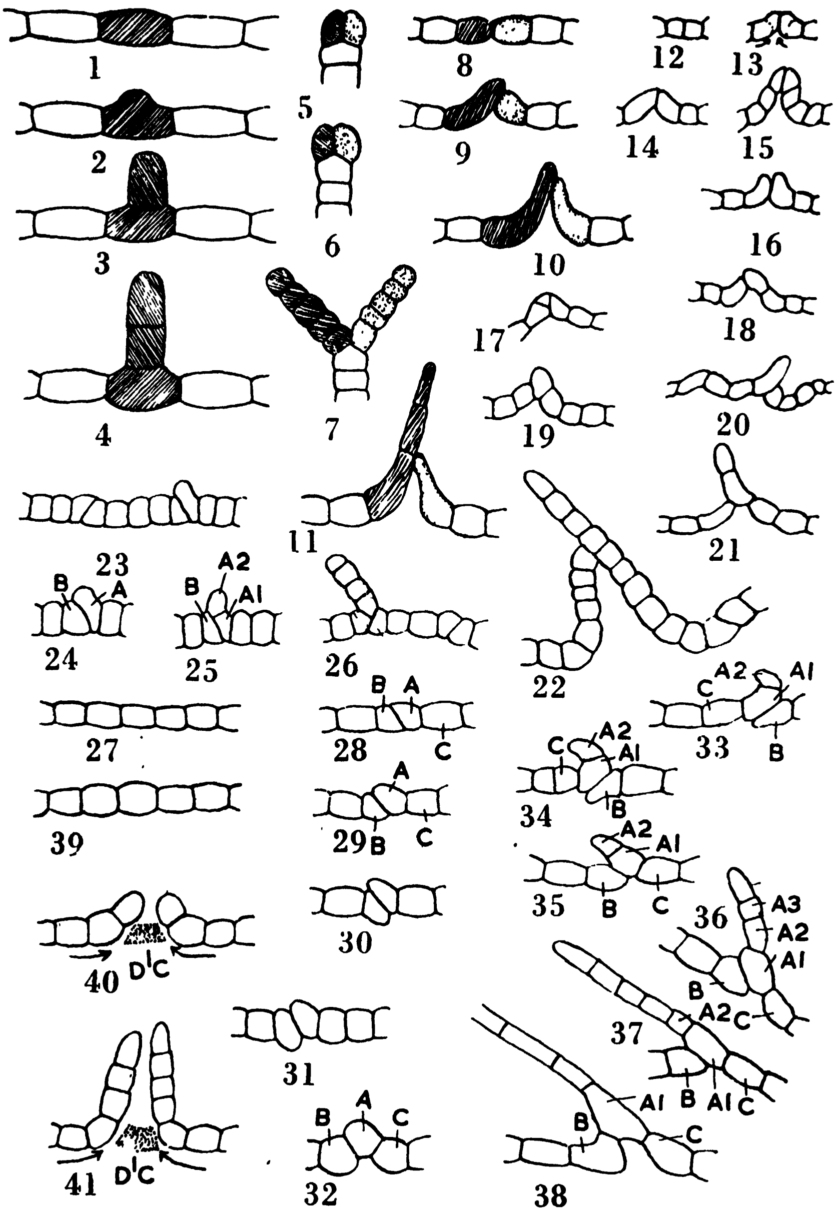


PLATE 7, Figs. 1–41. Diagrammatic representation of different modes of branching in the blue-green algae.

1–4. True lateral branching; 5–7. Dichotomous branching (after Frémy); 8–11. Reverse ' V '-shaped branching in *Mastigocladus laminosus* Cohn (after Frémy); 12–22. Reverse ' V ' - shaped brancing in *Brachytrichia quoyi* ( = *B. balani* (Ll.) Born. et Flah.) (after Ercegovic); 23–26. Reverse ' V '-shaped branching in a *Mastigocladus* sp. (original after Iyengar and Seshadri, G.); 27–38. Reverse ' V '-shaped branching in *Brachytrichia balani* (original after Iyengar and Desikachary); 39–41. False-branching. (DC = Dead cell).

cells *B* and *C*, and the division of *B*, and sometimes of *C*, a typical 'V'-shaped structure is formed. This essentially differs from the mode of branching described by Ercegovic. According to Ercegovic (*see* also Umazaki, 1956) a loop is formed first somewhat in the manner of the loop formation in certain *Scytonema* and that one of the arms of the loop grows over the top of the other and forms a branch. According to Iyengar and Desikachary a normal branch is formed first and then 'V'-shaped structure is formed below it (see plate 124).

Setchell and Gardner (1919, p. 111), give a slightly different version. At certain points in the filament lateral loops are formed sometimes only a few cells long, at other times many cells long. One cell at the end of the loop divides lengthwise cutting off a cell which becomes the basal cell of the branch which develops towards the surface, giving the appearance of dichotomous branching, although virtually a single cell of the filament gives rise to a single lateral branch at certain intervals.

This type of branching also occurs commonly in *Mastigocladus.* Bornet and Flahault (1887), and Frémy (1936) have studied the branching in this genus (Pl. 7, figs. 8–11). Two continuous cells of the main filament form two branches which are in contact at the apex. One of the branches advances over the other and becomes the branch at the apex. Iyengar and Desikachary (1954) and also Iyengar and Seshadri, G. (*see* Iyengar and Desikachary (1954)) give a different version of the mode of development (Pl. 7, figs. 23–26). According to these authors a cell in main filament divides obliquely into two cells (*A* and *B*) one of which (*A*) divides into an outer cell ($A_2$) and inner cell ($A_1$), The outer cell ($A_2$) divides to form a branch, cell *B* remaining attached to the basal cell of the branch. After the branch has been formed a typical reverse 'V'-shaped structure is formed with the branch resting on two basal cells. The two basal cells $A_1$ and *B* by a slight bulging on lower side, elongation and division give rise to the two arms of the advanced 'V'-shaped structure. There is a definite need for a study of branching in living material (see plate 128).

The branching in *Brachytrichia* and *Mastigocladus* are very similar and the former can be derived from the latter by a change in the position of the second cross wall. Occasional occurrence of the *Mastigocladus*-type variant of branching is seen *Brachytrichia* and *vice versa.*

Thus reverse 'V'-shaped branching or Mastigocladaceous branching is derived from the oblique division of a single parent cell instead of the longitudinal division (*see* also Borzi, 1914–17).

Iyengar and Desikachary (1954; *see* also Gardner, 1919; Drouet 1951; Schmidt 1954) consider this branching as a true branching owing to the fact that the organic continuity between the main filament and the branches is not lost (*see* also Iyengar and Desikachary, 1953; cf. Geitler, 1925b, 1936; Fritsch, 1945).

The lateral branching as is seen in *Hapalosiphon* also occurs in *Mastigocladus* and *Brachytrichia* (Gardner, 1919, p. 112; Iyengar and Desikachary, 1954, p. 106; *see* also Frémy, 1936; Fritsch, 1945).

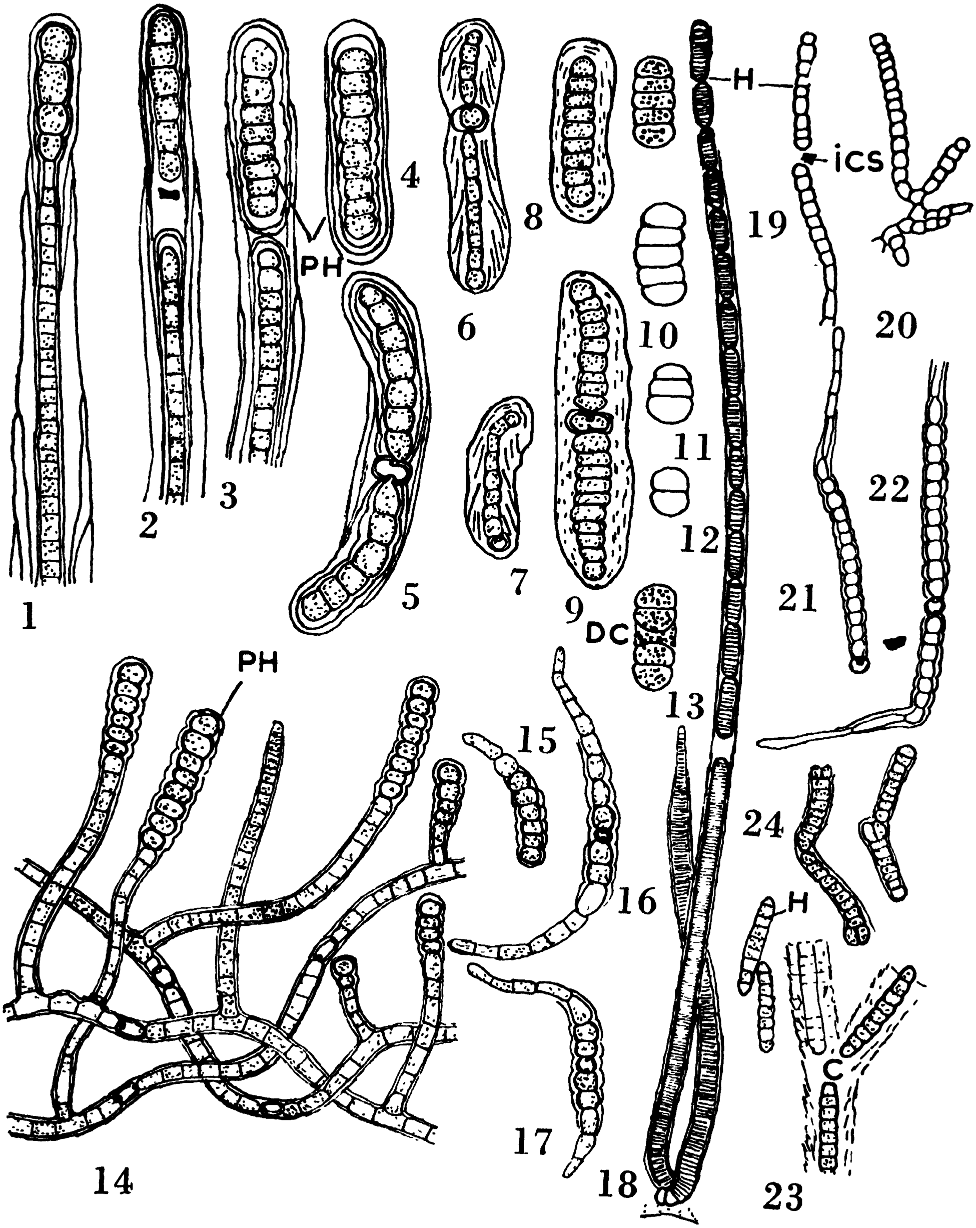


PLATE 8, Figs. 1–24.

1–5. *Camptylonema indicum* Schmidle, formation and germination of pseudohormogonia (hormocysts) (after Desikachary); 6–7. *Scytonema geitleri* Bharadw., pseudohormogonia (after Bharadwaja); 8–9. *Fischerella* sp. (*Fischerella anomala* Bharadw.?) pseudohormogonia (after Bharadwaja); 10–13. Hormogones of *Stigonema minutum* (Ag.) Hass. (after Geitler); 14–17. *Westiella intricata* Borzi, pseudohormogonia formation and germination (after Frémy); 18. *Calothrix confervicola* Kütz., hormogone formation (only a part shown) (after Bornet and Thuret); 19–22. *Nostochopsis lobatus* Wood em. Geitler, formation and germination of hormogones (after Desikachary); 23–24. *Loriella osteophila* Borzi, hormogones (H) and their germination (after Borzi); PH = Pseudohormogonium; DC = Dead cell.

### 2. FALSE BRANCHING.

In false branching (Pl. 7, figs. 39–41) a cell in the main trichome divides transversly and there is a break in the trichome between the daughter cells and the branch emerges out of the sheath at point of the breaking (Bornet and Flahault, 1885; 1886a; *see* also Geitler, 1932; Bharadwaja, 1933b; Gonzalez-Guerrero, 1933). The break in the trichome may be caused by the death of a cell or by the formation of discs of intercellular substance. One or both ends grow out of the sheath as false branches (e.g., *Scytonema*; *see* Bharadwaja, 1933b). In *Tolypothrix* (especially *Hassallia* section) only one of the free ends grows out as the branch and the other forms a terminal heterocyst (*see* Bharadwaja, 1932b). Rarely the trichome breaks near the intercalary heterocyst and then again one or two of the ends grow out and develop into false branches according to whether the break is on one side or both sides of the heterocyst (*see* Bharadwaja, 1933b). In certain species of *Scytonema*, the trichome becomes active and divides repeatedly. The entire portion of the trichome at that region increases in length and consequently forms a loop. This loop becomes more and more prominent (Geitler, 1936). Ultimately one of the cells at the apex of the loop dies and the two portions separate out as two false branches. The branches may also become separated by the formation of biconcave discs of intercellular substance (Bharadwaja, 1933b, fig. 5F, J-L). These false branches as they grow out develop new sheaths which proceed inwards into the parent filament to some distance.

False branching is very common in the Nostocales. They are also present in a number of genera of the Stigonematales such as *Hapalosiphon*, *Fischerellopsis* Fritsch, *Camptylonema* Schmidle and *Handeliella* Skuja.

A habit very much similar to false branching is reported by Bharadwaja (1933a) in *Aulosira pseudoramosa.* Here a large number of hormogones are formed and these germinate *in situ.* During germination their ends protrude out of the sheath and simulate false branching. A new sheath is secreted and it completely encircles the hormogones. In fact false branching can be considered as the germination *in situ* of hormogones which do not get liberated. In other words false branching is " a process of multiplication in which the fragments remain immobile and grow *in situ* (Bornet and Flahault, 1888; Fritsch, 1942; 1945).

## VEGETATIVE PROPAGATION AND REPRODUCTION

### I. HORMOGONES

These are small pieces of trichome with one to many uniform cells (cf. Schönleber, 1937) (Pl. 8, figs. 9–13, 18, 19). These are provided with a very delicate mucilaginous sheath sometimes not easily perceptible and are actively motile. Trichomes of *Oscillatoria* and *Cylindrospermum* which are in a state of

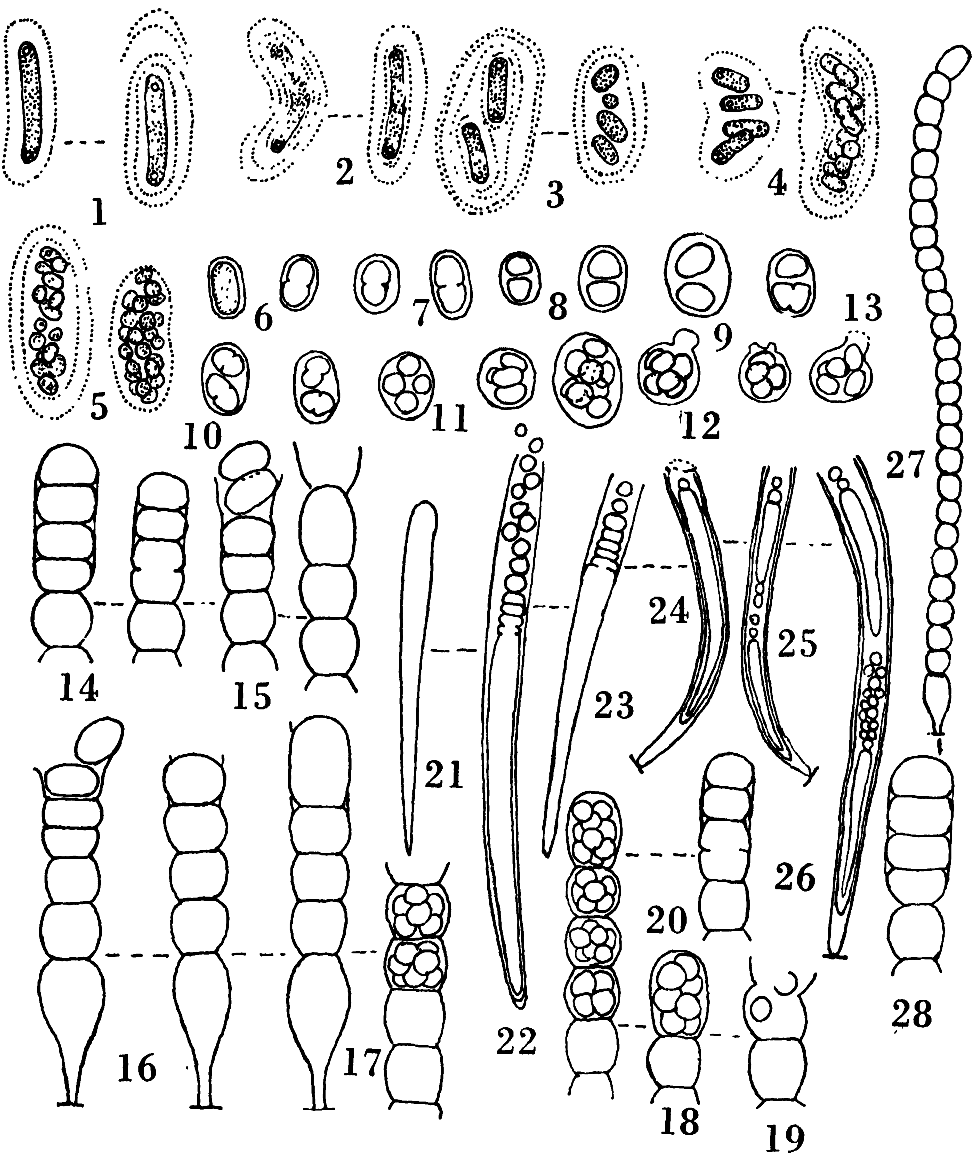


PLATE 9, Figs. 1-28.

1-5. *Aphanothece caldariorum* Richter, P., successive stages in nannocyte formation (after Geitler); 6-13. *Aphanothece bullosa* var. *major* Geitler, stages in the nannocyte formation (after Geitler and Ruttner); 14-20, 27, 28. *Endonema moniliforme* Pascher, endospore formation (after Pascher); 21-26. *Chamaesiphon curvatus* Nordst., exospore formation (21-23 after Geitler, 24-26 after Starmach).

permanent motility may be considered to be in a state of hormogone permanently (*see* Fritsch, 1945, p. 807). Hormogone formation is one of the most common modes, in some cases the only known mode of propagation in the Nostocales and Stigonematales ( = Hormogonales).

Hormogones are formed by the death of one or more intercalary cells or by the formation of special biconcave separation discs (biconcave discs of intercellular substance) (Pl. 8, fig. 19). Hormogones are formed from different portions of filaments. In the Oscillatoriaceae and Nostocaceae any portion of the trichome may get abstricted as a hormogone. In the Scytonemataceae and some Stigonemataceae they are generally formed from the apical portions of branches. In *Stigonema* (Pl. 12, fig. 15) and *Fischerellopsis* these are formed on special branches. In the Rivulariaceae these are formed from the intercalary meristematic zone after the hair portion is thrown off (Pl. 8, fig. 18). Similar hormogone formations are also described in *Brachytrichia* and *Mastigocoleus* (Setchell and Gardner, 1919; Iyengar and Desikachary, 1944).

Hormogones are generally liberated out of the parent sheath (Pl. 8, fig. 18) and are motile. They develop into new individuals (Pl. 8, figs. 21-22). In the heterocystous forms, a heterocyst (terminal or intercalary) is differentiated probably at the very beginning (for hormogones with heterocysts *see* Schönleber, 1937) (Pl. 8, figs. 21, 22; Pl. 12, figs. 14–17).

Formation of intercalary hormogones and their germination *in situ* is also known (*see* Brand, 1903, Bharadwaja, 1933a).

Gonzalves and Kamat (1954) describe a new method of hormogone formation in *Aulosira implexa* Born. et Flah. var. *crassa* Dixit. According to them hormogone formation in this alga is preceded by a break in the sheath on one side followed by a fragmentation of the trichome. The cells of the trichome near the deflected portion of the sheath die; thus the deflections come to encase small pieces of trichomes consisting of two to many cells which function as hormogones. Escape of the hormogones is brought about by the gelatinization of the deflected portion and the outer sheath near it. Thus the filaments break into a number of portions each enclosing two to many cells forming a hormogone. Such a mode of hormogone formation is known in no other alga and Dixit (1936) himself apparently has not observed this phenomenon.

The nature of the movement and its response to external stimuli is the same as in the case of the trichomes (Pl. 13, fig. 1).

## II. PSEUDOHORMOGONIA

(Hormocysts or hormospores of others).

In the Scytonemataceae and some Stigonemataceae small pieces of trichome (*see* also Frémy, 1929), homologous to the hormogones and similarly formed instead of being motile enclose themselves in a thick lamellated pigmented sheath and become perennating bodies (Pl. 8, figs. 4, 8, 14). These

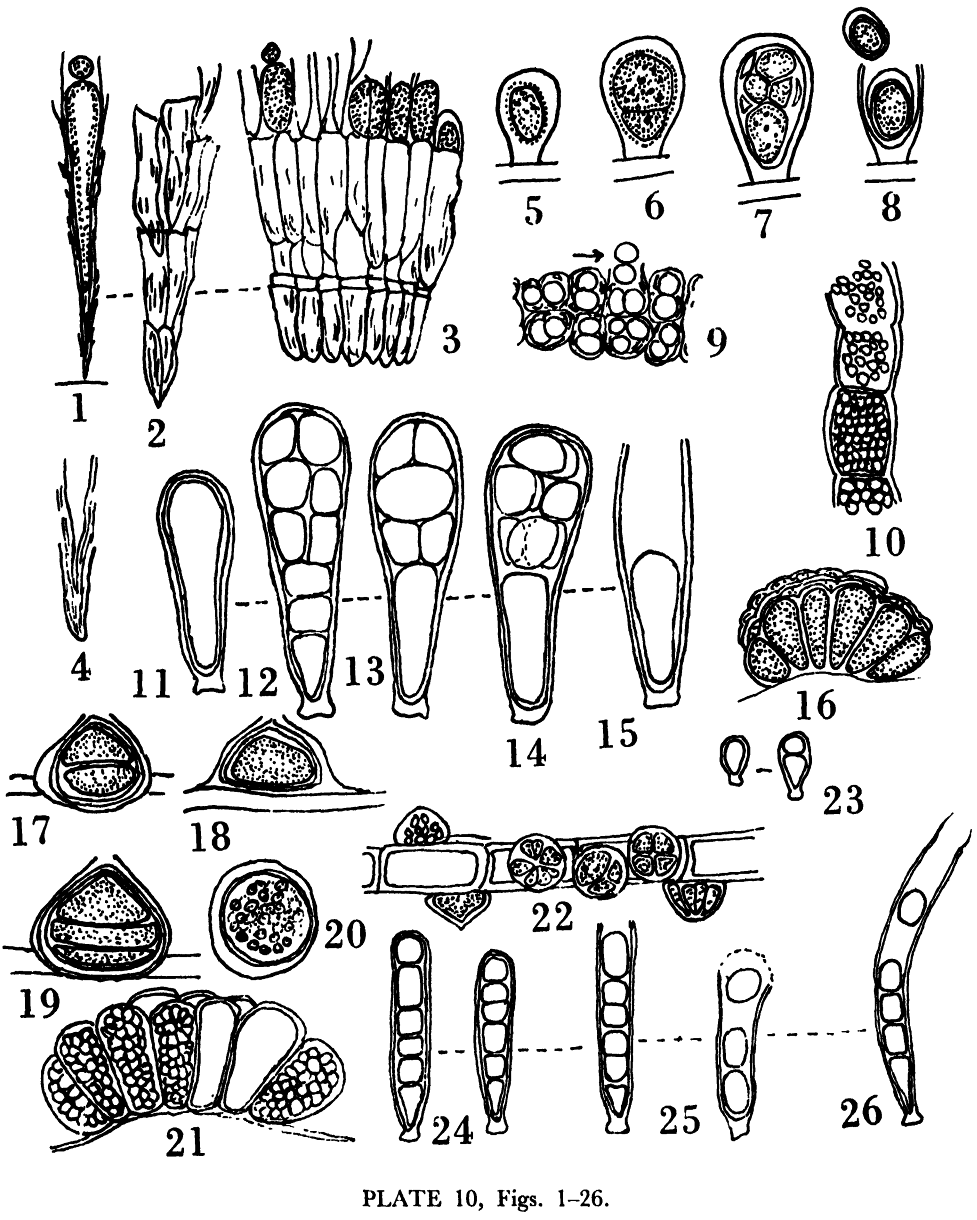


PLATE 10, Figs. 1–26.

1–4. *Chamaesiphon fuscus* (Rostaf.) Hansgirg, colony formation (after Geitler); 5–8. *Dermocarpa incrassata* (Lemm.) Geitler, endospore formation showing the basal residual protoplast (after Lemmermann); 9. *Siphononema polonicum* Geitler, exospores (only a portion shown) (after Geitler); 10. *Herpyzonema intermedia* W. v. Bosse, showing endospores (after W. v. Bosse); 11–15. *Dermocarpa clavata* (Setchell and Gardner) Geitler, endospore formation (after Geitler); 16, 21. *Dermocarpa prasina* (Reinsch) Bornet et Thuret, endospores (after Bornet and Thuret); 17–20. *Dermocarpella hemisphaerica* Lemm., endospore formation (after Lemmermann); 22. *Dermocarpa hemisphaerica* Setchell et Gardner, endospore formation (after Setchell and Gardner); 23–26. *Stichosiphon sansibaricus* (Hieron.) Drouet et Daily, exospore formation (after Geitler).

have been called 'pseudohormogonia' by Schmidle (1900b; *see* also Desikachary, 1948) and ' hormocysts ' of Borzi (1914–1917; Cholnoky, 1935).

On germination the two ends grow out (Pl. 8, fig. 5). An intercalary heterocyst is developed and a new plant is formed (Pl. 8, fig. 5, 9, 16, 17). Whether these pseudohormogonia undergo a period of rest or not is not definitely known. But their germination *in situ* has been reported (Frémy, 1929, 1930; Desikachary, 1948).

Pseudohormogonia are known in *Westiella* (Pl. 8, figs. 14–17), *Camptylonema* (Pl. 8, figs. 1–5), *Scytonema* (Pl. 8, figs. 6, 7), *Fischerella* (Pl. 8, figs. 8, 9), *Leptopogon*, *Handeliella*, *Spalaeopogon* (?) etc., (Borzi, 1914-17; Schmidle 1900b; Frémy, 1924; Bharadwaja, 1933b; Cholnoky, 1935; Skuja, 1937; 1949; Desikachary, 1948).

In *Westiellopsis,* Janet (1942) describes what are called by her as ' pseudohormocysts '. These are more closely related to endospores.

## III. ENDOSPORES

Endospores are small spores formed endogenously within a cell (sporangium) by the quick succession of divisions in three planes (e.g. *Dermocarpa*) (Pl. 10, figs. 11–15). Endospores are commonly formed in certain unicellular members which do not have any other mode of reproduction. In *Endonema* occasionally only two spores are formed from each cell. In *Dermocarpella* (Lemmermann, 1907; *see* also Feldmann, J. & G., 1953) the division is transverse (Pl. 10, figs. 17–20). The upper cell becomes converted into a single endospore and gets liberated. The lower cell remains vegetative and is capable of forming new endospores. In *Dermocarpa hemisphaerica* the division is vertical-radial (Pl. 10, fig. 22). In *Dermocarpa xenococcoides, Dermocarpa prasina* etc. the entire cell becomes converted into a sporangium (Pl. 10, fig. 21). But in some others, e.g., *D. clavata*, the first division of the protoplast is transverse cutting off a basal cell or protoplast and an upper cell which by repeated divisions forms a number of endospores (Pl. 10, figs. 11–15). After the liberation of these spores the basal cell enlarges and a similar endospore formation takes place (Pl. 10, figs. 5–8). In certain others (e.g. *D. suffulta*) the basal cell does not again form endospores.

Endospores superficially resemble aplanospores of the green algae. Endospores are generally described as naked spores, which secrete a thin wall on liberation. Endospores with a wall are also known (Geitler, 1921, p. 204).

Endospores which are commonly formed in the Dermocarpaceae have also been reported in *Siphononema*, (Pl. 10, fig. 9), in some of the filamentous forms and in the coccoid forms but only rarely, e.g., Oscillatoriaceae (Pl. 13, figs. 18–19) (Brand, 1903, p. 46; Fritsch, 1912), Nostocaceae (Brand, 1903a, p. 49; Fritsch, 1904b), *Herpyzonema* (Pl. 10, fig. 10) (W V. Bosse, 1913) and *Gomphosphaeria* (Schmidle, 1901).

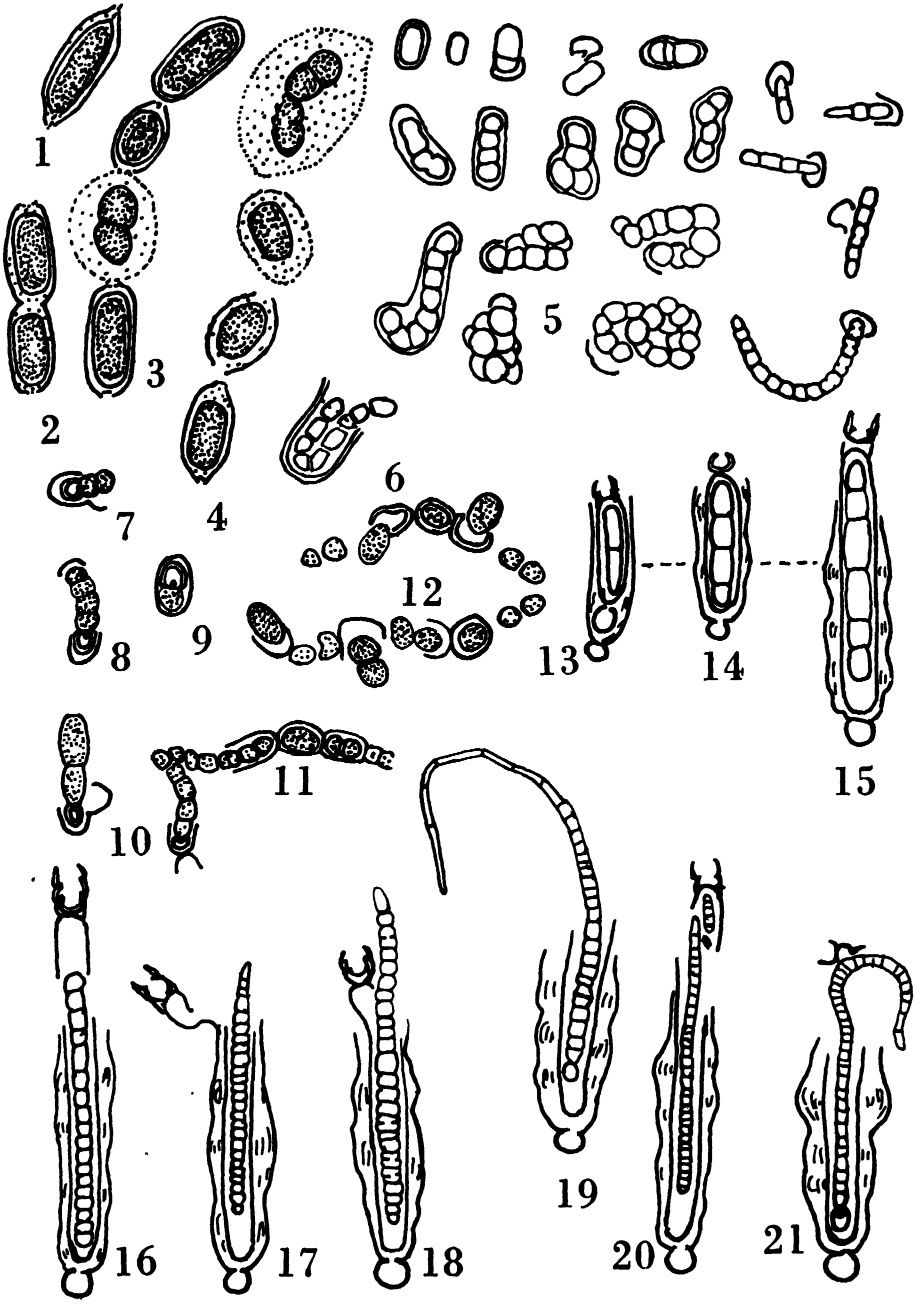


PLATE 11, Figs. 1–21. Germination of spores (akinetes).

1–4. *Nostoc ellipsosporum* (Desm.) Rabenh. (after Geitler and Ruttner); 5. *Nostoc punctiforme* (Kütz.) Hariot (after Harder); 6. *Cylindrospermum licheniforme* Kütz. (after Bristol); 7–9. *Anabaena kuetzingiana* De Toni ( = *A. inaequalis* (Kütz.) Born. et Flah.) (after Canabaeus); 10. *Anabaena cylindrica* Lemm. (after Canabaeus); 11–12. *Anabaena azollae* Strasb. (after Fritsch); 13–21 *Gloeotrichia natans* Thur. (original).

In *Westiellopsis* Janet (1942) describes what are called by her ' pseudohormocysts ', clusters of cells formed terminally on erect lateral branches by repeated transverse and longitudinal divisions. From the cells the contents escape as single gonidia. These gonidia are really single endospores (*see* Fritsch, 1945, p. 854).

## IV. NANNOCYTES

In genera such as *Gloeocapsa, Aphanothece, Microcystis, Chlorogloea* etc., the cells undergo repeated and successive divisions without any obvious cell-enlargement, so that groups of very small cells are formed in each parent cell (*see* Setchell and Gardner, 1918, *Gl. crepidinum*, as endospores) (Pl. 9, fig. 6–13). These are generally naked protoplasts and are called ' nannocytes '. These germinate *in situ* to form new colonies. Fritsch (1945, p. 812) rightly regards this as endospore formation (*see* also Setchell and Gardner, 1918).

## V. EXOSPORES

In *Chamaesiphon* and *Stichosiphion* spores are serially abstricted from the open ends of sporangia by transverse division (Pl. 10, figs. 23–26). The abstricted spores are surrounded by a delicate membrane. The protoplast is continuously active. In some cases the exospores do not get liberated and germinate *in situ* giving rise to colonies of various kinds (e.g. *Chamaesiphon fuscus* (Rostaf.) Hansgirg) (Pl. 10, figs. 1–4).

## VI. PLANOCOCCI

These are single celled hormogones which show a kind of slow creeping movement and are known in *Desmosiphon* (Borzi, 1916), and probably in *Stauromatonema* also (Frémy, 1929, cf. Fritsch, 1945, p. 849).

## VII. SPORES (AKINETES)

Resting spores (Akinetes) are commonly met with in the Nostocaceae (Pl. 5, figs. 12, 13, 16) and the Rivulariaceae as also in a few members of the Scytonemataceae and Stigonemataceae (Pl. 12, figs. 1, 3) and rarely in the Chroococcales (Pl. 5, fig. 14) (Novacek, 1934; Brand, 1900; Itzigsohn, 1875; Kirchner, 1900) and Chamaesiphonales (Geitler, 1925a). These akinetes are very large cells, thick walled and have accumulated food reserves in the form of cyanophycin granules. The cells loose photosynthetic pigments though the outer parts of the walls may develop coloration. The spore has two wall layers (Gomont 1888; Fritsch, 1905) corresponding to the cell-sheath and the inner investment but are much thickened. These do not give cellulose reaction. Centroplasm is not very well defined. In the fully mature akinetes there are no gas-vacuoles. Metachromatin granules are also not present (Elenkin and Danilov, 1916).

Spores are formed in specific positions especially in relation to the heterocyst. In some genera (*Cylindrospermum* spp., *Gloeotrichia,* spp., *Anabaena*

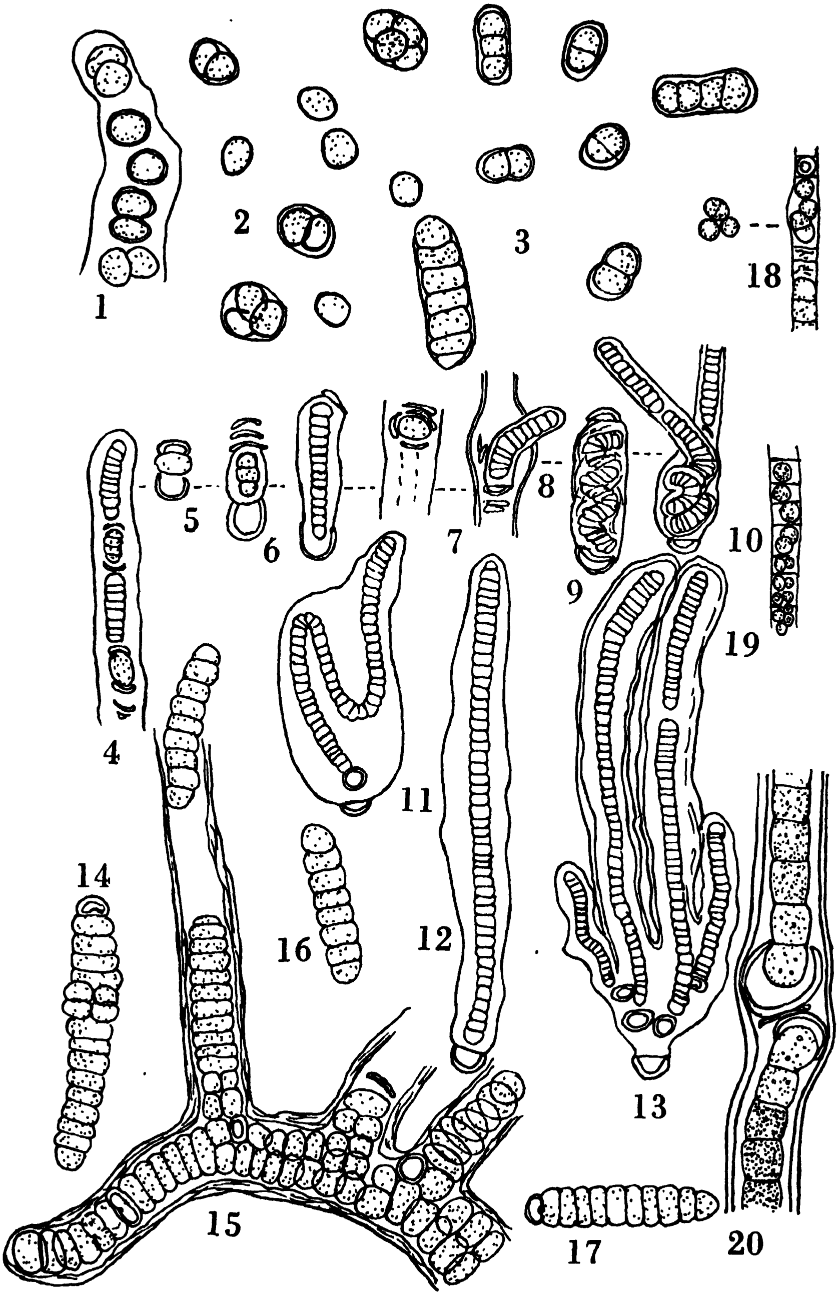


PLATE 12, Figs. 1–20.

1–3, 14–17. *Stigonema turfaceum* (Bréb.) cooke, 1, groups of spores, 2–3, germination of spores, 14–17, formation of hormogones and their germination (all after Borzi); 4–13. Germination of the heterocysts in *Tolypothrix elenkinii* Hollerb. (after Hollerbach); 18–19. Gonidia (endospores) formation in *Phormidium uncinatum* (Ag.) Gom. (after Brand); 20. *Tolypothrix penicillata* Thur. var *tenuis* Hansg., rejuvenation of the contents of the heterocysts (after Brand).

spp.) the spores are formed generally singly, rarely more on one or both sides of the heterocysts (Pl. 5, fig. 12). In others they are formed in short or long chains. Spore formation in *Nostoc* spp., and in some *Anabaena* spp., (Pl. 5, fig. 13) first starts in between the heterocysts and proceeds towards it. In *Anabaena* spp., it starts from heterocysts and progresses away from it. Very often entire lengths of trichomes get converted into a series of spores occasionally interrupted by living or dead cells.

Some spores germinate immediately (Bharadwaja, 1933a; Fritsch, 1904; Harder, 1917; Spratt, 1911; Singh, 1942; Palik, 1941) while others require a resting period (Rose, 1934). They remain viable for a long period of time (Bornet and Flahault, 1886; Borzi, 1878a; Bristol, 1919; Lipman, 1941), and can withstand dessiccation and high temperatures (Glade, 1914; Janczewski, 1874).

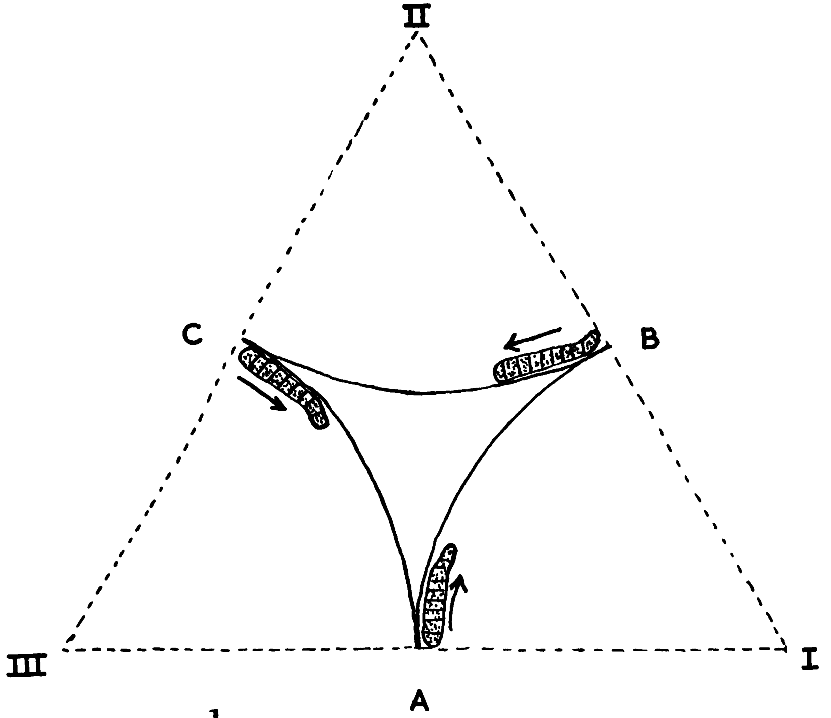
Germination of the spores has been observed by many workers and spores of many genera (Plate 11) have been studied (De Bary, 1863; Borzi, 1878; Beck v. Mannagetta, 1898; Bornet and Thuret, 1880; Janczewski, 1894; Brand, 1903; Gardner, 1904; Fritsch, 1904; Spratt, 1911; Glade, 1914; Harder, 1917, 1918; Bristol, 1919, 1920; Canabaeus, 1929; Frémy, 1929, 1936; Geitler, 1925a; Palik, 1941). The stages of germination are generally very similar. The protoplast divides first into a two-celled germling or a few celled germling. The inner investment is first dissolved. The outer investment is dissolved either only at one end (Pl. 11, figs. 5–12, 15–21) or entirely (Pl. 11, figs. 1–4) and the germling gets liberated (Pl. 11, figs. 7, 10). The liberated germling generally develops a heterocyst and then forms a group of filaments by hormogone formation. In rare cases the entire germling divides into a number of hormogones straightaway.

Harder (1917b) has shown that the percentage of germination of spores in *Nostoc*, is proportional to the meter-candle-hours of exposure.

# BIOLOGY OF BLUE-GREEN ALGAE

## I. PLANKTONIC FORMS AND WATER BLOOMS

A number of blue-green algae especially belonging to the Chroococcales, Oscillatoriaceae, Nostocaceae occur ordinarily as planktonic forms, while a few others may occur in plankton in one or the other stages of their life-history, though ordinarily cannot be called planktonic forms. Huber-Pestalozzi (1938) lists as many 44 genera and 251 species which occur in freshwater plankton and this may be considered quite a good percentage considering that the total number of genera of blue-green algae may be placed about 150 with about 1,500 species.



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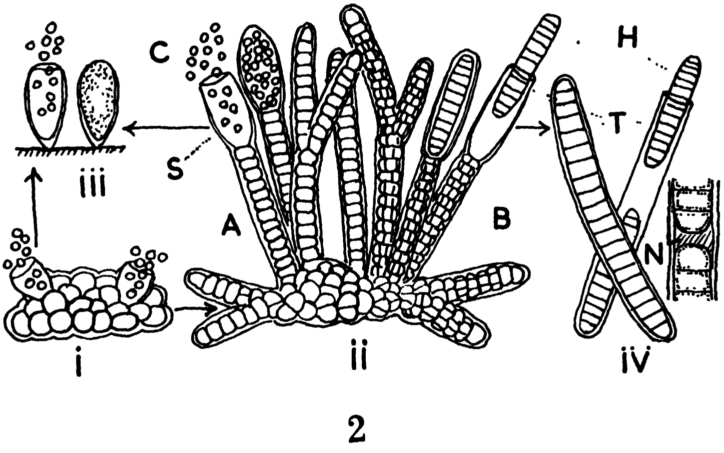

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PLATE 13, Figs. 1–2.

1. Schematic representation of the movement of a hormogone of *Phormidium* sp. The movement is from A–B, B–C, C–A (after Brand); 2. Schematic representation of morphological evolution of the Cyanophyceae; I. Archéthallus of the Chroococcales; IIA. Protothallus with typical sporocysts (S) forming coccospores (C), the Pleurocapsales; IIB. the Protothallus with trichomes (T) forming hormospores (H), Stigonematales, polystichous; III. the Coccothallus of the primitive Chamaesiphonales; IV. the Trichomothallus of the primitive Nostocales (N = necridia) (after Chadefaud).

Several species of the blue-green algae grow in abundant quantities so as to color the entire body of water and in some cases these are caused by a single species. Such growths are called ' Water blooms '. Smith (1924) and Huber-Pestalozzi (1938) list the species so far known to form water blooms. Huber-Pestalozzi includes 40 species and varieties and their names are reproduced here below. *Microcystis aeruginosa*, *Microcystis elabens, M. flos-aquae, M. ichthyoblabe, M. ochracea, M. prasina* (?), *M. scripta, M. viridis, Coelosphaerium dubium, C. kuetzingianum C. naegelianum, Anabaenopsis elenkinii, Aphanizomenon flos-aquae, A. recurvum* (?), *Nostoc carneum, N. linckia, Nodularia spumigena, Anabaena catenula, A. catenula* var. *affinis, A. circinalis, A. circinalis* v. *cyrtospora, A. flos-aquae, A. levanderi, A. macrospora, A. macrospora* v. *robusta, A. spiroides, A. utermöhli, Gloeotrichia echinulata, G. natans*, *Spirulina gomontiana, S. thompsoniana* (?), *Arthrospira platensis, Oscillatoria aerugescens* (?), *O. agardhii, O. prolifica, O. rubescens, O. planctonica, O. redekei, Lyngbya limnetica* and *L. hieronymusii*. In India especially blooms caused by *Microcystis aeruginosa* and *Trichodesmium* spp., are common. The former, especially, forms permanent water blooms in many temple tanks in Ceylon and S. India (Crow, 1923a; Iyengar, 1938). The factors that promote such abundant growth seem to be shallowness, warm temperatures, high nitrogenous and phosphorus content and a good supply of half bound carbonates.

*Trichodesmium erythraeum* and *Trichodesmium thiebautii* are known to form water blooms for more than a century in the Indian ocean, Bay of Bengal, and the Arabian Sea. These species grow in bundles and rafts of filaments. The toxicity is variable and occasional blooms cause fish mortality (*see* Aiyar, 1936; Chacko, 1942; Chidambaram and Mukundan Unni, 1944; Ballantine and Abbott, 1957). The mechanism of death seems to be caused more by the choking up of gills rather than due to any toxin produced by the alga.

These water blooms have been a cause of annoyance especially in drinking water supplies, choking up of slow sand filters and are reported to have caused the mortality of fish and animals. The principal species are *Aphanizomenon flos-aquae, Microcystis aeruginosa, Microcystis flos-aquae, Gloeotrichia echinulata*, and several species of *Anabaena* (Prescott, 1948; Ingram and Prescott, 1954). Instances of mortality and the injurious effect on livestock have been reported even in the last century (Francis, 1878; Gillam, 1925, Nelson, 1903; Baldwin and Whipple, 1906; Haine, 1918). Recently *Microcystis toxica* has been reported from South Africa to be toxic to animals (Steyn, 1945; Stephens, 1948) Toxic and lethal effects of *Microcystis flos-aquae, Anabaena flos-aquae, Aphanizomenon flos-aquae* on certain animals was demonstrated by Fitch *et al.* (1934).

The exact nature of the toxic substance in *Microcystis* is not known. It is water soluble and is thermostable at neutral pH, but is labile in alkaline. It diffuses slowly through a cellophene membrane. The toxin acts as a cytotoxin (*see* Ashworth, C. T., and Mason, M. R., 1946; Ingram and Prescott, 1954; Shelubsky, M., 1951; Saunders, 1957).

Hughes *et al.*, (1958; *see* also 1955; Zehnder, A., *et al.*, 1956) have studied the toxicity of *Microcystis aeruginosa* on mice. They have been able to distinguish two distinct factors, one a slow death factor and the other a fast death factor. The slow death factor causes death in 4–48 hours preceded by symptoms of piloerection and dyspnoea and this factor is detected only with freshly harvested cells. The other causes death with 2–3 hours preceded by pallor and convulsions. This second factor is an endotoxin which is detected only when cells become leaky or disintegrate. The phycobilins that are often released on disintegration have nothing to do with the toxin. Incubation and freezing only served to release the endotoxin already present in the cells and disintegration proved to be just as effective in releasing the fast death factor. The fast death factor withstands alkaline conditions of the medium for long periods. Fast death factor was detected in the culture filtrate on and after the third day.

### MARINE AND OTHER SALT WATER FORMS

Blue-green algae occur in many saline situations, the chief of which is the sea. Probably 20 per cent of the known blue-green algae occur in saline situations, majority of which are truly marine. In India 85 species are known from saline situations including 50 marine species. The Chamaesiphonales and the Pleurocapsales form the preponderant content of marine forms while a number of species belonging to the other orders are also marine. A majority of these forms occur in the intertidal and the supratidal regions, while a few are planktonic.

Salinity as a single factor plays an important role in the vegetation of the saline series of habitats. The salinity of the sea water is in general around 35 grams per kilogram of sea water and lesser in the colder waters and probably greater in the more enclosed portions of the sea. There is a great variation in the salinity content at the mouth of rivers and that too subject to seasonal changes. The flora of the inland saline lakes and estuarine salt lakes and salt pans are somewhat different from that of the truly marine habitats. A number of species have been reported from both these situations.

Hof and Frémy (1932/33) differentiate between the algae which tolerate or survive in brine and those that grow and multiply in brine. As an example of the halophilic as against the halotolerant can be cited the polybelpharid, *Dunaliella salina*. While it is doubtful which of the reported blue-green algae is really halophilic most of them can be described as halotolerant. Feldmann (1951) divides the algae into euryhaline and stenohaline,—those living in brines as hyperhaline and those of the brackish water as hypohaline.

Blue-green algae have been reported from salt pans growing in brine, in many countries, where they form as it were a mat at the bottom. This mat formation is of great importance in salt manufacture in solar salt works. It is reported that during the removal of salt after manufacture from the beds care is taken to see that the algal mat is not disturbed or removed (van Buschman, 1909). Two blue-green algae have been identified, viz., *Microcoleus* *chthonoplastes* and *Oscillatoria* spp., together with a number of other blue-green algae as minor partners, *Lyngbya aestuarii, Microcoleus tenerrimus* and *Aphanocapsa marina.* These algal mats are known from Istria in the Adriatic, Portugal, and Italy (van Buschman, 1909; Zanco, 1931), France (Furer, 1900), California (Baas-Becking, ex Hof and Frémy, 1932/33), Siberia (Cavara in Woronichin, 1929; Woronichin, 1929), Tunisia and Algeria (Seurat, Gauthier-Lierre, and Feldmann, ex Hof and Frémy, 1932/33) and Indonesia (Hof and Frémy, 1932/33).

Besides the algae which go into mat formations a number of other blue-green algae have been reported from salt pans and also have been isolated from cultures using crude salt samples from different countries. Salts more than 3 years old did not yield any blue-green algae. These following species are known. *Oscillatoria tambi, O. brevis, O. brevis* v. *variabilis, O. kuetzingiana* v. *crassa, Phormidium foveolarum, Ph. fragile, Ph. ambiguum, Ph. tenue, Spirulina major, Sp. subsalsa, Merismopedia glauca, Chroococcus turgidus, Anabaena torulosa, Aphanocapsa pulchra, A. littoralis, Aphanothece halophytica, Dzensia salina.* The majority of the forms which inhabit the saline situations do not tolerate or live at very high salt content, the maximum number being recorded below 2 molar salt content and only a few above 3·6 molar salt content. Only a handful of species exist at the latter concentration to be called true halophilic. Reports of occurrence of algae at high saline content limits are available. Blue-green algae occur in some brines in Southern France at 27 per cent brine (Hase, 1926) and a *Rivularia* species is reported from California (Scott ex Hof and Frémy, 1932-33). Woronichin (1929a-c) reported a number of these forms living at 11–27 per cent salt content in lakes in Kulundinsteppe in Siberia and other lakes. In many cases the saline content data are not reliable and it is considered by some (Hof and Frémy, 1932/33) that these forms are really not halophilic but are only halotolerant as these species do not occur in cultures above 2 Molar concentrations. However, *Dzensia salina, Aphanocapsa littoralis* and *Aphanothece halophytica* together probably with *Anabaena torulosa* are considered to be truly halophilic by Hof and Frémy (1932/33). Feldmann (1951) considers that *Microcoleus chthonoplastes* as euryhaline (both hypo-and hyperhaline).

These halophilic forms show a large amount of variation in cell size and shape and structure in different molar solutions. Brines are characterised by the presence of ‘ giant cells ’. The giant cells often present a variegated appearance and this is considered to be due to localised segregation or spatial separation of green and blue pigments, within the cells. Resistance to high concentrations of electrolyte may be caused by the formation of cysts or protective impervious or electrically charged envelopes (Hof and Frémy, 1932/33). The conditions are comparable to physiological drought.

This capability to live in halotolerant conditions is attributed to the peculiar characteristics of the blue-green protoplasm especially its plasmolysis and deplasmolysis characteristics, which are quite distinct from what is seen in the other plant cells.

The limit of 3·6 molar strength at which the algae in general do not thrive in brine cultures is corroborated by the fact that in nature in the solar salt works the algae disappear about this concentration (*see* Tressler, 1951, p. 22). Further explanation seems to be forthcoming from the work of Walter (1923, 1931; *see* also Baas Becking, 1931) who has pointed out the incapacity of organisms to live in less than 85 per cent water content which condition exists about the same level of salt content at which these organisms disappear.

In India the flora is yet to be investigated in the case of many of the salt lakes. The only detailed accounts of flora that are available are those of the Salt lakes of Calcutta (Martens, 1870a, b; Martens, 1871a, b; Krempelhuber, 1869; Biswas, 1926). About 35 species are known but the exact salt content of these lakes especially those at which these species occur are not known. Ghose (S. L.) has recorded one species each of *Arthrospira* and *Aphanothece* (*A. halophytica*), and an *Anabaena* sp., from the Sambhar salt lakes (*see* Aggarwal, 1951). The first was reported growing upto 28° Be and the other two upto 17° Be.

### II. EPILITHIC AND ENDOLITHIC BLUE-GREEN ALGAE

Blue-green algae inhabit calcareous substrata both as epilithic and endolithic forms. Calcareous rocks, shells, corals are the common substrata for these algae.

Among the commonest epilithic blue-green algae may be mentioned *Calothrix* spp., and *Pleurocapsa* spp.

A number of genera are endolithic. The entire plants or parts of plants perforate into the calcareous substratum. This dissolution of the calcareous substrata is directly due to the action of a solvent secreted by the plant (Bachmann, 1915; Ercegovic, 1925; Koster, 1939). However some of the Chroococcales inhabit the Dolomites where they occupy preformed clefts or crevices formed more by weathering than due to any dissolution by the plant (Diels, 1914; also Marchessoni, 1939).

*Hyella* spp., *Plectonema terebrans* and *Mastigocoleus testarum* inhabit both marine and freshwater molluscs.

Ercegovic (1929) has described a number of perforating forms which are mainly marine eg., *Kyrtuthrix, Dalmatella, Solentia, Hormathonema, Schizothrix, Podocapsa, Pleurocapsa, Brachynema, Radaisia, Epilithia, Scopulonema, Tryponema,* and *Lithonema.*

Extensive calcareous deposits by freshwater blue-green algae is known in the present as well as geologic times (Howe, 1932, p. 59; Wieland, 1930; Baumann, 1913; Magdeburg, 1929–32, 1933; Thunmark, 1926). *Rivularia* spp., (*R. dura, R. biasolettiana, R. haematites*), *Schizothrix* spp., *Petalonema crustaceum, Aphanothece castagnei* etc., form calcareous tuffs (*see* Magdeburg, 1929–32, 1933; and Thunmark, 1926). Wieland (1930) describes a reef forming alga which is related closely the modern *Phormidium.* Similar extensive deposits diatoms, and Chlorophyceae are present at different temperatures in thermal waters and this is against the thermophilic character being given to the Cyanophyceae alone. Vouk has noted the presence of *Mastigocladus laminosus* in a resting or latent condition at the usual temperature of the water or even in a dry condition and that it is able to exist for months or even years without losing the capacity for active life, growth and reproduction. He considers that thermophily is not a characteristic feature of the blue-green algae alone but extends also to other algae to a lesser extent. According to him the capacity of the other groups of algae to exist at higher temperatures is a thermophilic adaptation phenomenon and the same should be said also of the Cyanophyceae which are the most euriphious organisms. He concludes that the entire present thermal vegetation is only an adaptation flora to waters of high temperature.

## V. COLD-WATER FORMS

Blue-green algae are tolerant of low temperatures also. *Phormidium* sp. has been reported to form extensive layers in the Antarctic lakes. Other blue-green algae are also reported (Fritsch, F. E., 1912; W. & G. S. West, 1911; *see* especially Taylor, 1954). According to Taylor (1954) *Calothrix* and *Rivularia* are the commonest blue-greens inhabiting marine Arctic areas, while in the fresh water areas *Gloeocapsa* and *Nostoc* are most abundant.

## VI. SYMBIOSIS AND OTHER ASSOCIATIONS OF BLUE-GREENS

A number of blue-green algae live endophytically in other algae. *Richelia intracellularis* (Pl. 15, figs. 6-10) lives endophytically in *Rhizosolenia* spp. (Schmidt, 1901; Karsten, 1907). Another Nostocaceae (*Nostoc symbioticum*) occurs in *Geosiphon pyriformis* a siphonous green alga (Wettstein, 1915; Fritsch, 1935). Species of *Lyngbya, Calothrix, Phormidium* (Pl. 15, fig. 13) and *Cyanodictyon* are reported in the mucilage of other algae.

Associations between unicellular blue-green algae and coccoid and palmelloid green (?) algae are known. These latter forms are generally devoid of chromatophores. The blue-green algae are coccoid forms. *Gloeochaete wittrockiana* (Pl. 14, fig. 2) (Dangeard, 1889; Korschikoff, 1917; Geitler, 1923; Pascher, 1931) and *Chalarodora azurea* (Pl. 15, figs. 11, 12) (Pascher, 1931b) have in them *Synechococcus* or *Rhabdoderma*. *Glaucocystis nostochinearum* (Pl. 14, fig. 4) (Geitler, 1923) and *Cyanoptyche gloeocystis* (Pl. 14, figs. 5, 6) (Pascher, 1931) have small blue endophytes which are generally called ' cyanellae.' Geitler (1923) showed very clearly that these endophytes are not chromatophores as was earlier described but are really blue-green endophytes with an internal structure analogous to the ordinary blue-green algae (*see* also Korschikoff, 1921). Skuja (1949) has described *Glaucocystis cingulata* and *Gloeochaete wittrockiana* from Burma. Pascher describes associations between certain bacteria and blue-green algae as ' Syncyanoses ' (*Chlorochromatium,* Lauterborn, 1906, 1916; West and Fritsch, 1927, Buder, 1913; *Spirillum*, Pascher, 1914a; *Oicomonas,* Pascher, 1914a). Syncyanoses is said to occur under putrefying conditions.

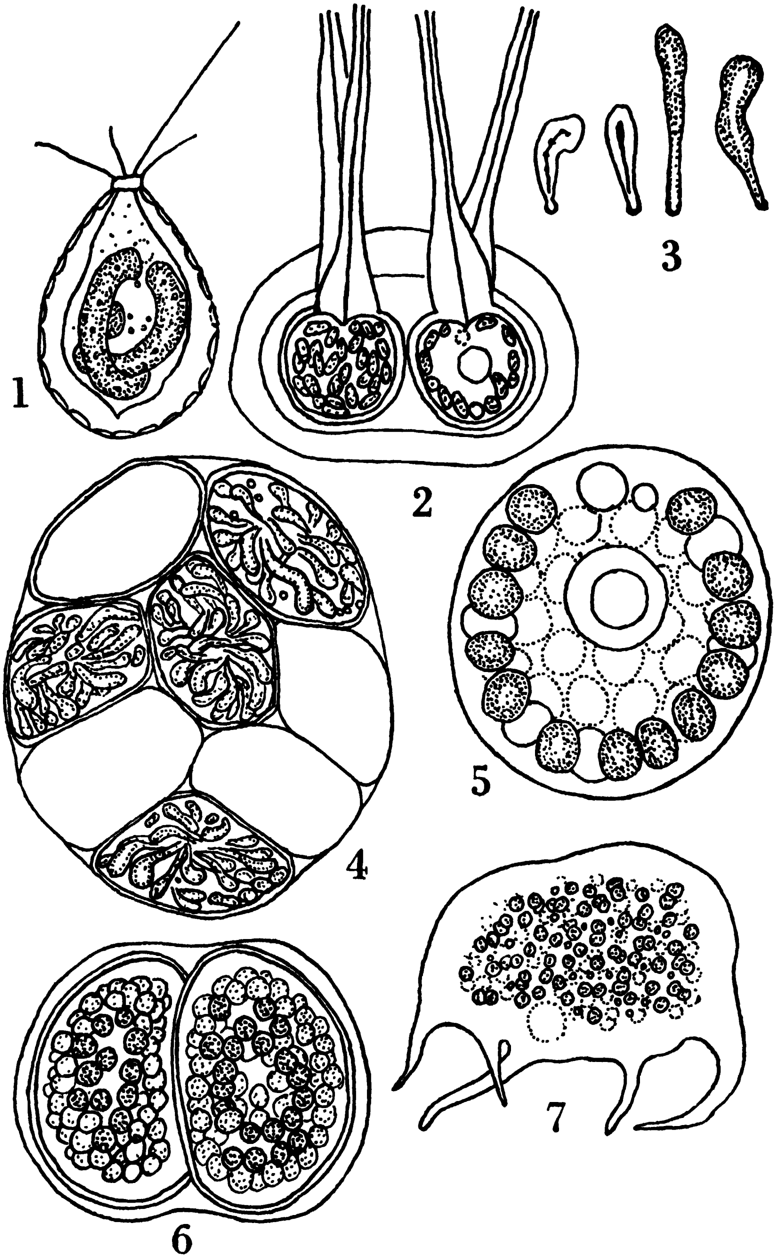


PLATE 14, Figs. 1–7.

1. *Paulinella chromatophora* Lauterb., in optical longitudinal section showing blue-green cells (after Pascher); 2. *Gloeochaete wittrockiana* Lagerh., two-celled colony showing blue-green cells (after Pascher); 3. Blue-green cells from *Glaucocystis nostochinearum* Itzigs. (after Geitler); 4. *Glaucocystis nostochinearum* with blue-green cells (after Geitler); 5. An optical view of *Cyanoptyche gloeocystis* Pascher showing the arrangement of the blue-green cells (after Pascher); 6. Two-celled colony of *Cyanoptyche gloeocystis* Pascher showing the blue-green cells (after Pascher); 7. An *Amoeba* with blue-green symbiotic algae (after Pascher).

Pascher (1914a, 1929c) distinguishes two types of association: (*i*) Ektocyanoses where the blue-green algae do not become an endophyte (*Oicomonas* and *Spirillum*) and (*ii*) Endocyanoses, where the blue-green algae is an endophyte. Geitler (1932) thinks the term Syncyanoses of Pascher can suitably represent both the types of associations.

Similar association between blue-green algae and flagellates and animals are known. Endophytic blue-green algae occur in some colorless flagellates, e.g., *Peliaina cyanea* (Pascher, 1931b) (fig. 121), *Cyanophora paradoxa* (Korschikoff, 1921 and Pascher, 1929c), *Cryptella cyanophora* (Pascher, 1931), *Chroomonas* (*Cryptomonas*) *gemma* (Playfair, 1921); and *Paulinella chromatophora* (Lauterborn, 1895; Hoogenrand, 1927; Geitler, 1927; Pascher, 1929c). In most of these cases the blue-green component gets distributed between the daughter cells during cell division and are present in their reproductive bodies (e.g., *Cyanoptyche*, Pl. 15, fig. 1). In cases where there is only one (or a few) blue-green component, it undergoes division simultaneously with the division of the cell in much the same fashion as the chromatophores do in some algae (e.g., *Peliaina* (Pl. 15, figs. 3-5) and *Cyanophora*).

Pascher describes an amoeba having in it more than a hundred blue-green components.

The exact physiological relationship between the partners is not known. That the algae do play a part in the nutrition is borne out by the elimination to a greater or lesser extent the holozoic nutrition characteristic of the hosts. The algae have not shown any capability for free growth, though it is known that these cells continue to live when separated from the host. Cyanophycin granules are not found in these blue-green components; starch, is, however, reported in the hosts (Pascher, 1939). Fritsch (1945) suggests that a substance is formed by this partnership, which neither partner can produce by itself. In evolution the blue-green partners which entered the body of the host as prey, appear to have resisted digestion and hence stayed permanently as partners (*see* Brehm, 1917).

Other associations of blue-green algae are also known. *Phormidium mucicola* is also reported to grow in the mucilage of rotifers viz., *Floscularia mutabilis* and *Conochilus unicornis* (Huber-Pestalozzi and Naumann, 1929). West and Annandale (1911) described *Microcystis orissica* and *Dactylococcopsis pectinatellophila* growing in the mucilage of a polyzoan, *Pectinatella burmanica.*

Mortensen and Rosenvinge (1934) described an association between *Dactylococcopsis* and sea urchins.

Many lichens have in them blue-green algae. Only in a few cases have the algae been identified up to the species. The genera are *Chroococcus, Gloeocapsa, Nostoc, Scytonema, Stigonema, Rivularia* and *Dichothrix.*

The nature of association between the algae and fungi differs from lichen to lichen. In some the alga predominates (*Nostoc* and *Stigonema* in *Collema*

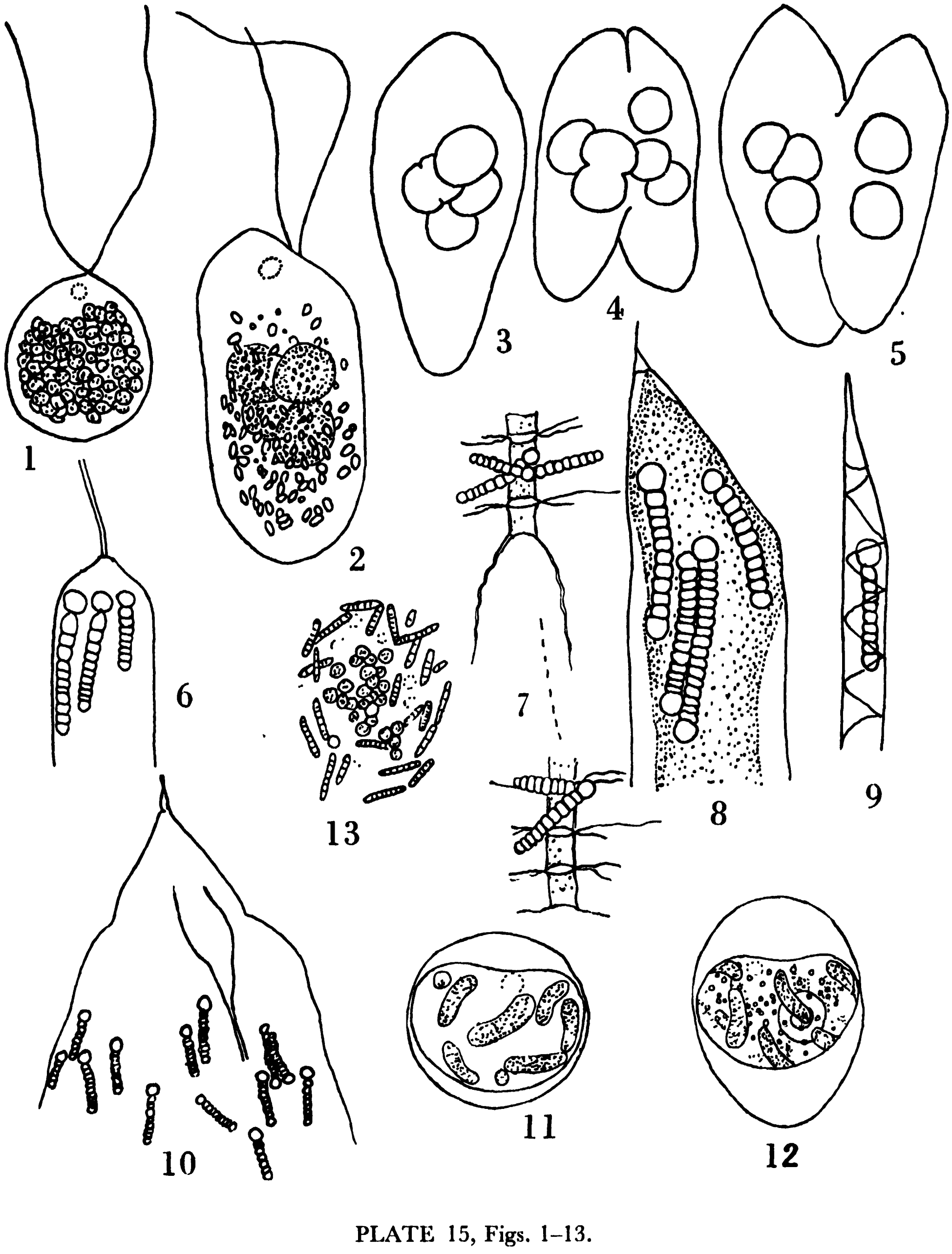


PLATE 15, Figs. 1–13.

1. Swarmer of *Cyanoptyche gloeocystis* Pascher, with blue-green cells (after Pascher); 2. ***Peliaina cyanea*** Pascher, with four blue-green cells (after Pascher); 3–5. Division stages of *Peliaina* showing the division of the blue-green cells (after Pascher); 6–10. ***Richelia intracellularis*** J. Schmidt in *Rhizosolenia* spp. and on *Chaetoceros contortum*. (8 after Schmidt, 7 after Karsten and the rest after Subrahmanyan); 11, 12. *Chalarodora azura* with blue-green cells (after Pascher); 13. *Phormidium mucicola* with *Microcystis aeruginosa* Kütz. (after Huber-Pestalozzi and Naumann).

and *Ephebe*). In others the growth of the alga is profoundly modified making definite identifications nearly impossible (*Dichothrix* in *Placynthium*, *see* Geitler, 1934). The hyphae may remain in close contact with the algae or may even penetrate the algal cells, and cause damage. In a few cases the fungi have been pushed out by the host. The blue-green algal cells react generally by an increase in the size of the infected cells and formation of firm membranes.

Symbiotic association between blue-green algae and other plants are also known. *Nostoc* and *Anabaena* have been reported from Bryophytes (*Blasia, Clavicularia, Anthoceros*), Ferns (*Azolla*), Gymnosperms (*Cycas, Zamia*) and Angiosperms (*Gunnera, Trifolium alexandrinum* root nodules).

Both the hosts and the algae have been grown separately (*see* Pierce, 1906; Huneke, 1933; Limberger, 1925; Johnsson, 1894; Life, 1901; Takesige, 1937), in some cases even better (Pierce, 1906). Some hosts when grown alga-free have been reported to suffer in one or more ways (Huneke, 1933). Molisch (1925) and Takesige (1937) feel that the algal partner is necessary for the host. The nature of these association is not clearly known. It has been described as space parasitism leading to heterotrophic nutrition (Harder, 1917; Watanabe, 1924; Geitler, 1932). Some suggest that the association is one of advantage to host in the supply of nitrogen through the nitrogen-fixing organisms (De, 1939; Fogg, 1942; Fritsch, 1945, p. 874).

## VII. SAPROPELIC FORMS AND COLORLESS FORMS

Only a few sapropelic and colorless forms are known. *Oscillatoria angusta* Koppe (1924) is a bottom living colorless form. Sapropelic forms are generally yellowish-green in color and inhabit bottom areas. The commonest known are Cyanochloridaceae, some Chroococcales (*Chroococcus quaternarius* Zalessky, *Microcystis* spp., *Aphanocapsa distans, Aphanothece* spp.), *Oscillatoria* spp., *Lyngbya* spp., and *Pseudanabaena biceps* (*see* Lauterborn, 1913, 1916; Utermöhl, 1925; Zalessky, 1926; Bocher, 1946b, 1949).

## VIII. PARASITIC BLUE-GREENS

Heterotrophic nutrition among blue-green algae (?) is also known e.g., *Anabaeniolum* (Langeroon, 1924; Petit, 1926; Hocquette, 1933, 1937), *Oscillospira* (Chatton and Perard, 1918), *Simonsiella* (Simon, 1922; Felinger, 1924) and *Oscillatoria* sp. (?) (Leger and Bory, 1932). Movements very similar to *Oscillatoria* and the formation of hormogones (?) have been described in *Oscillospira* (Delaporte, 1934). The structure of the cells is very similar to the blue-green algae (Delaporte, 1934, 1939). Similarly *Anabaeniolum* has the structure of a blue-green alga (Nadson and Krassilnikov, 1928). These genera have been found to be parasitic on man and in the intestines of animals.

## PATHOLOGY OF BLUE-GREEN ALGAE

Simple parasitization of the algal cells by Fungi have been reported by a number of workers. Changes in the consistency of the mucilage, coloration of the sheath, enlargement and ultimate degeneration of the infected cells are some of the reactions of the host to the parasitization (Braun, 1855; *see* Dangeard, 1890; Fritsch, 1907; Skuja, 1948; Jaag and Nipkow, 1951; Drouet, 1954; Drouet and Daily, 1956; Fjerdingstad, 1955; Sparrow, 1936). Lemmermann (1910) gives a list of fungi attacking various blue-green algae. Parasitic attack of the following blue-green genera have been reported: *Chroococcus, Microcystis, Oscillatoria, Anabaena, Nostoc, Aphanizomenon, Cylindrospermum, Tolypothrix* and *Calothrix.*

Fott (1951) describes a chytrid (*Phlyctidium anabaenae* Fott) on *Anabaena macrospora* Klebs, which attacks only the neighbouring cells of the heterocysts. He suggests that the heterocysts secrete an enzyme (*see* also Canabaeus, 1929) and this gets transferred to the neighbouring cells through the pore. This enzyme attracts the swimming zoospores which become attached to cells touching the heterocysts. Similarly *Rhizophidium subangulosum* (Braun) Rabenhorst seems to attack only the terminal cells of trichomes of *Aphanizomenon gracile* (?) and *Oscillatoria tenuis* var. *sub-fusca* while another species (*R. globator* (Br.) Schröder) parasitises on the intercalary cells.

Desikachary (1944) described the reactions of *Gloeotrichia raciborskii* to a parasitic attack. The reactions are nearly similar to those of fungal attacks reported earlier. The parasite was, however, not identified by him. Dr. Hilda Canter Lund (personal communication) has suggested that it appears to be a protozoan parasite.

## FOSSIL BLUE-GREEN ALGAE

Blue-green algae have been reported from fossils but that they are blue-green algae is questioned by some (*see* Fritsch, 1945). All the same these fossils afford no data as of use in phylogeny. No heterocysts have been reported so far in a fossil condition. Most of the fossils exhibit a tubular structure and are considered as the empty sheaths of blue-green algae (Pollock, 1918; Seward, 1931; cf. also Cayeux, 1910; Pice, 1937).

*Girvanella* with quite a few species have been reported from the Cambrian to Cretaceous having a dominant role in the formation of oolites (Pice, 1927, 1934; Bornemann, 1887; Rothpletz, 1891; Seward, 1894, 1898). This genus may be related, if not identical, to the modern *Symploca* (Plate 16; *see Symploca jurassica* Frémy and Dangeard, 1936 = *Girvanella minuta auct. pro parte*). *Nostocites* (*N. vesiculosa*) and *Archaeothrix* (*A. problematica*) reported from Carboniferous are supposed to be oscillatoriaceen in affinity. *Gloeocapsamorpha* has been reported from the Ordovician or Siberian (Zalessky, 1919, 1928) and is related

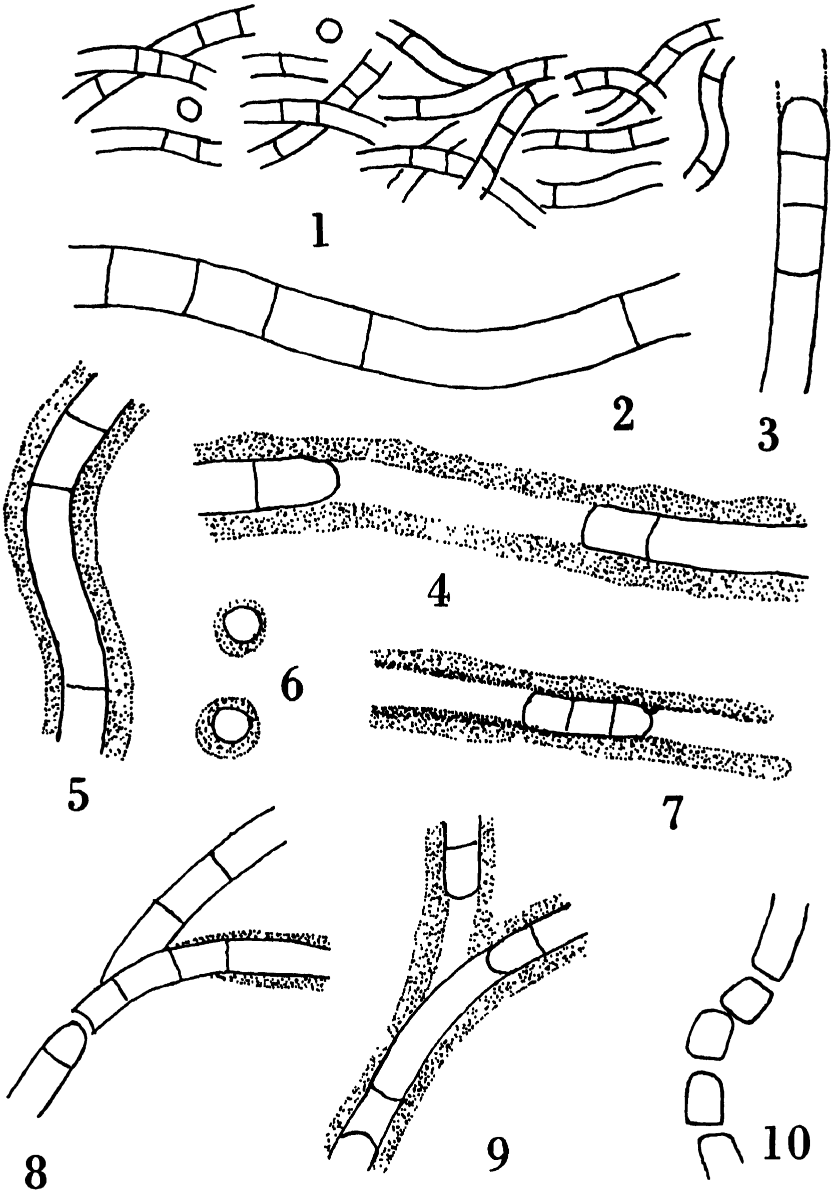


PLATE 16, Figs. 1–10.
*Symploca jurassica* Frémy et Dangeard (after Frémy and Dangeard).

to the modern *Gloeocapsa* (*see* also *Gloeocapsites* and *Gloeothecites* in Zalessky, 1917). *Gloioconis subtetrapedia* is known from the Carboniferous and Permian. Among other genera often described as blue-green algae may be mentioned, *Newlandia, Camasia, Collenia, Cryptozoon* and *Zonotrichites* (*see* Bornemann, 1887; Walcott, 1914, 1917; Rothpletz and Giesenhagen, 1922; Goldring, 1938; Seward, 1931).

From India only a few fossil blue-greens are known. S. R. Narayana Rao (1944) has reported *Symploca jurassica* from the Cullygoody Limestones of Trichinopoly which is considered to be upper Jurassic in age. *Aphanocapsa* has been reported by Mehta (1954) from permocarboniferous beds of South Rewa. Goswami's (1955) *Scytonema* gives a clear definition of a false branching, represented by two empty sheaths of geminate branches. The remains of the trichomes are not seen. Rao (1957) reports a *Synechocystis* from the tertiary lignites from Bikaner.

## CLASSIFICATION AND PHYLOGENY

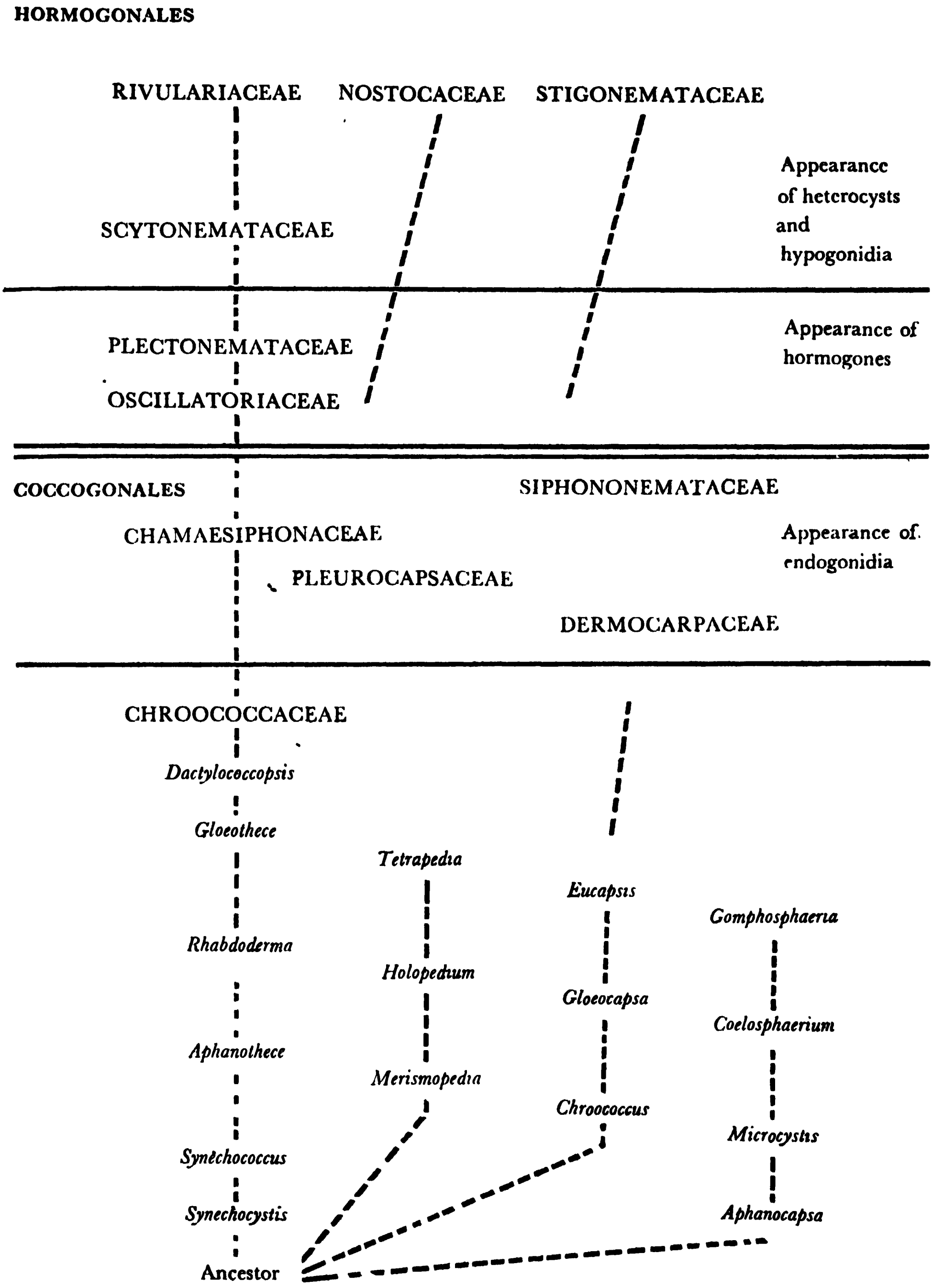
Geitler (1925b), Elenkin (1917, 1934; 1936), Fritsch (1942, 1944, 1945) and Papenfuss (1955) have reviewed the classification of the blue-green algae and evaluated the criteria involved. The author will in the present account deal only with the most important ones of the many classifications.

During the last century only the coccoid (colonial and palmelloid) and the filamentous members were known. The blue-green algae were generally divided into two tribes, Coccogoneae, characterized by unicellular reproductive bodies and the Hormogoneae (Nematogenae, Nostochinées) reproducing by a few celled short pieces of the trichome (hormogones) (*see* Thuret, 1875). A number of workers have dealt with each of these separately; the Chroococcaceae by Nägeli (1849) and Hansgirg (1888b and 1892) and the Hormogoneae by Thuret (1875), Bornet and Flahault (1885, 1886, 1888) and Gomont (1892). The Hormogoneae was further divided into Trichophoreae (forms with hair) and Psilonemeae (forms without hair). These two subtribes in all include five families, Oscillatoriaceae, Nostocaceae, Scytonemaceae, Stigonemaceae or Sirosiphonaceae and Rivulariaceae (*see* also Rabenhorst, 1865).

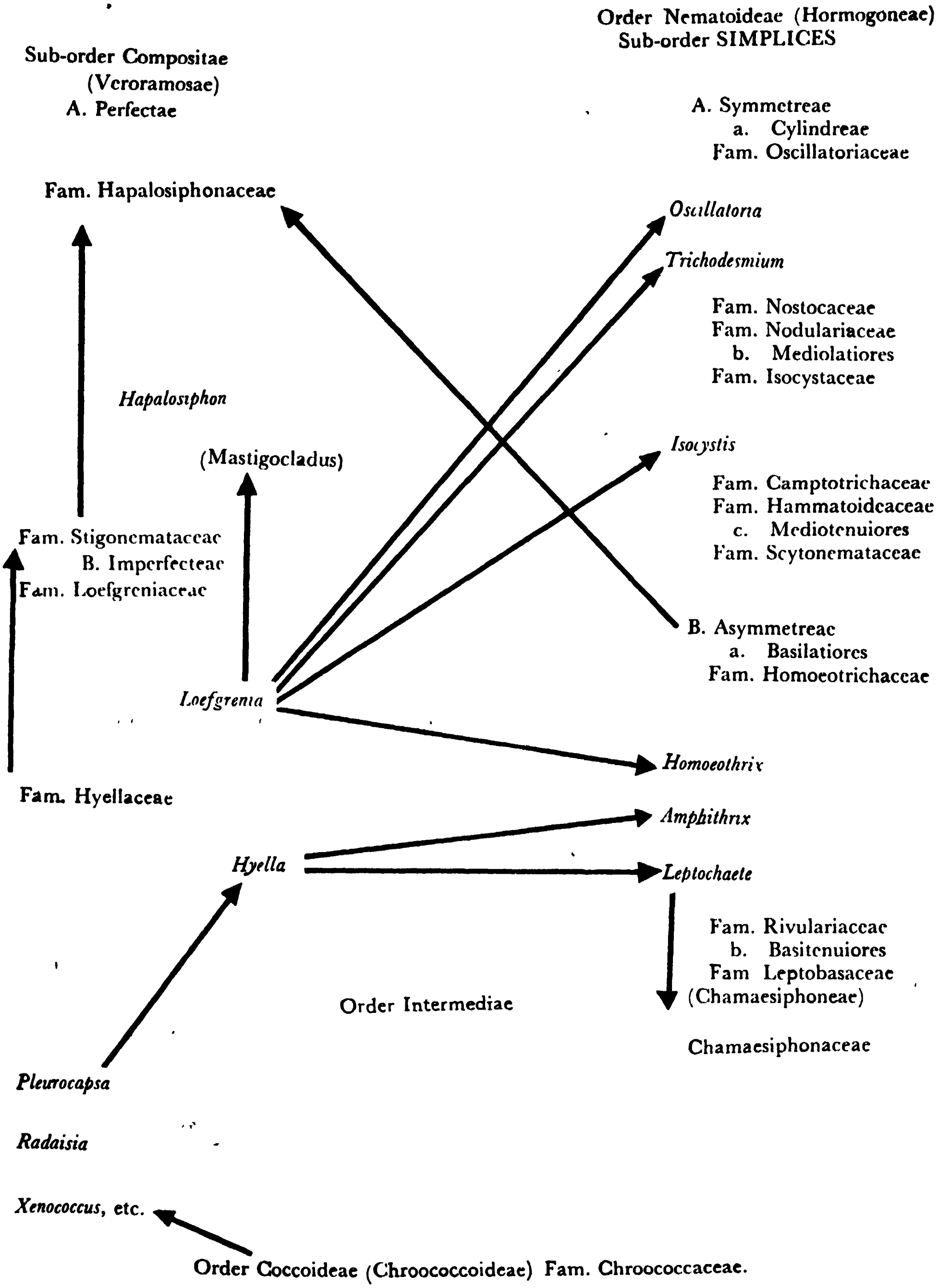
Borzi (1882) created the family Chamaesiphonaceae(*see* also Hansgirg, 1892; Kirchner, 1898) to include forms such as *Chamaesiphon* and *Clastidium.*

All these families, two in Coccogoneae and six under Hormogoneae were accepted by Kirchner (1898) who gave the first comprehensive treatment of the entire blue-green algae.

The filamentous forms include both which are branched and unbranched. The branching is of two types, false branching and true branching (for a detailed account of the different types of branching (*see* pp. 32-37).



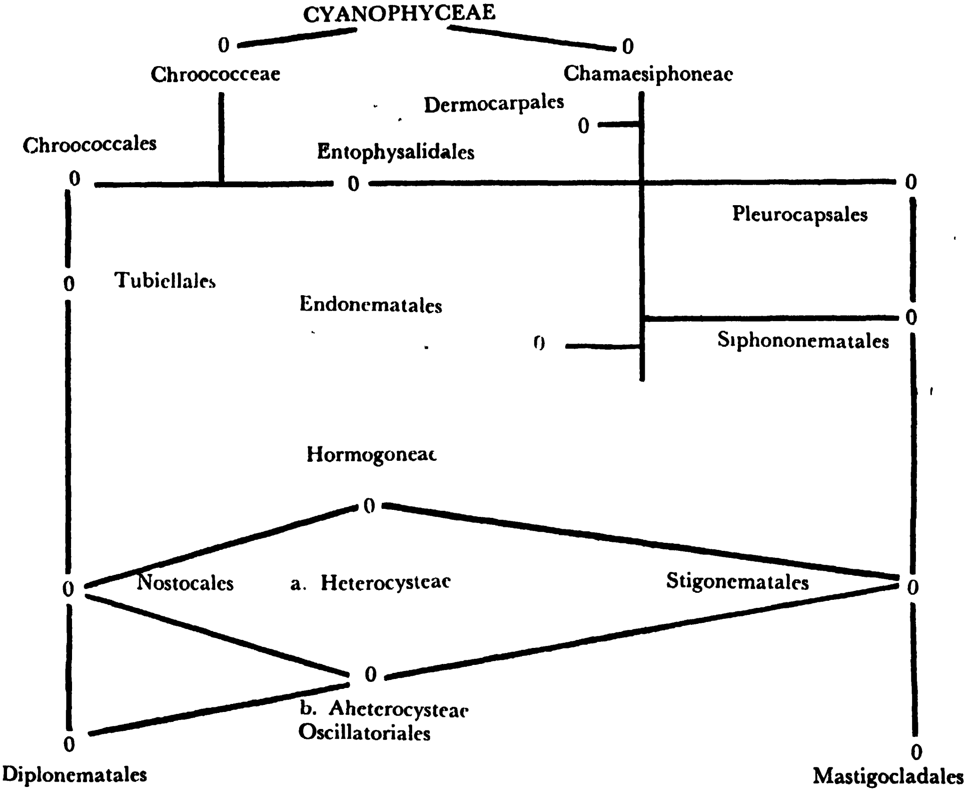
Geitler (1925b) lays great stress on the similarity between the genus *Siphononema* and its possible link with *Stigonema*. The former has a Gloeocapsoid habit when mature and this he compares with a similar stage in *Stigonema*.



Geitler thinks that the Stigonematales have probably evolved from the Chamaesiphonales. He considers the heterocystous forms as primary and the non-heterocystous condition to be secondary. Geitler's concept of the interrelationship may be represented as follows (representation not Geitler's).

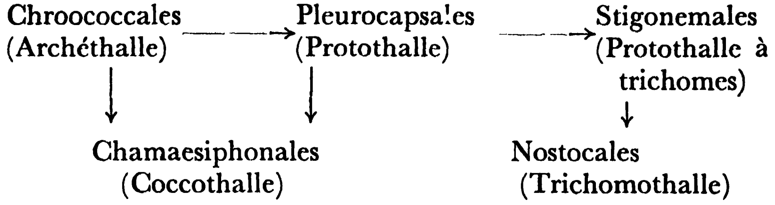
Elenkin (1917) laid great stress on the Hyellaceae and Loefgreniaceae and derived from these the different families of the Hormogonales (see p. 64).

In 1936 (*see* also 1938, 1949), however, he followed Geitler (1925b) in placing the Oscillatoriaceae at the end and suggests a two-way derivation of the Hormogonales, one way from the Chroococcaceae through the genus *Tubiella* and a second way through *Siphononema*. The genus *Tubiella* was described by Hollerbach (1934) and consists of a large number of short 2–3 celled trichomes arranged in cylindrical mucilaginous sheath and appears to be closely related Diplonematales, Oscillatoriales and Mastigocladales are put at the bottom being probably latest evolved.



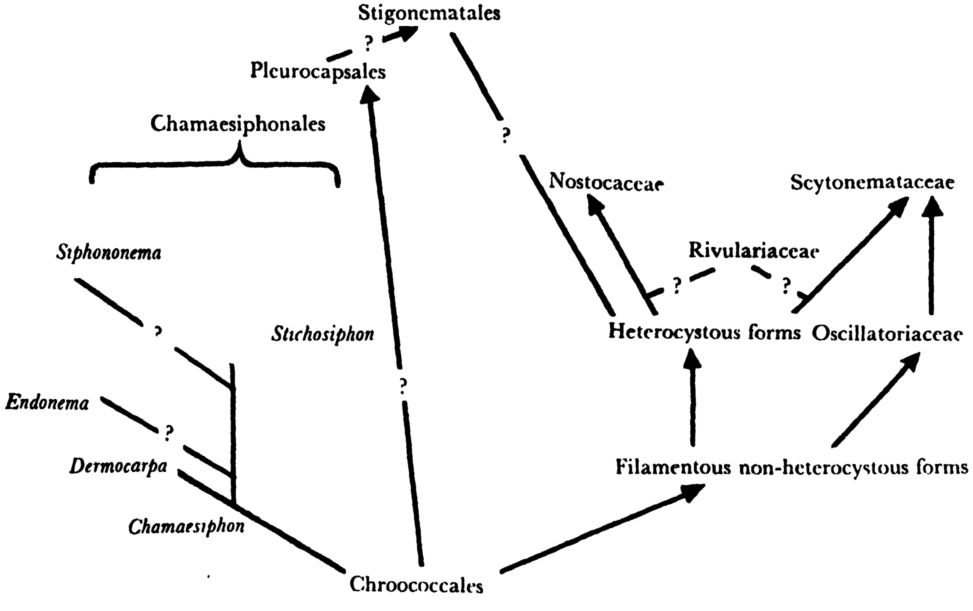
(after Elenkin 1936).

A somewhat similar evolution is also suggested by Chadefaud (1951). Plate 13(3) illustrates his view. According to him the primitive blue-green thallus ' archethallus was a chroococcaceous alga reproducing by unicellular non-motile spores' coccospores (endospores) formed in sporangia (sporocysts). From the archethallus has developed forms with ' protothallus ' both with polystichous and monostichous conditions and reproducing by endospores and hormospores which lead on to the Pleurocapsales and the Stigonemales. Nostocales are derived from the latter (*see* the schematic representation).



(after Chadefaud 1951).

From the latter stock are formed the Hormogonales (trichomothallus) by regressive evolution. The Chamaesiphonales (coccothallus) is probably derived both from the Chroococcales and the Pleurocapsales.



(Fritsch, 1942).

According to Fritsch (1939, 1942a, b, 1944, 1945) the heterotrichous habit together with the high state of organization of the thallus with the protoplasmic connections etc., marks out the Stigonematales as the most highly evolved. Similarly the Pleurocapsales also appear to be highly evolved (Fritsch, 1942), pointing out to some sort of a link with the heterocystous true branched Stigonematales. Fritsch suggests that the Nostocaceae, and Scytonemataceae, might have been derived from a simple *Oscillatoria*-like ancestor and that the Rivulariaceae shows affinities to both these families.

The present author supports Fritsch's view of the origin of the Hormogonales and that the Stigonematales are morphologically the highly evolved. Iyengar and Desikachary (1946) have suggested that *Johannesbaptistia* represents the highest expression of the filamentous tendency in the Chroococcales. It is easily possible to derive an *Oscillatoria*-like filament if the daughter cells in *Johannesbaptistia* do not separate away after division (cf. origin of the filamentous green algae, *see* Smith, 1950; Smith, 1954). Such a tendency is exhibited to a certain extent in *Tubiella* Hollerbach (*see* also Elenkin, 1934, 1936, 1938; Kisselew, 1947). From such a simple non-heterocystous member other heterocystous members have probably evolved. Some of the heterocysteae being derived by a secondary reduction cannot be ruled out.

The author feels that the mode of branching is a very characteristic feature of the blue-green algae and the separation of the Nostocales and Stigonematales is highly desirable.

Geitler (1932) suggests that the filamentous tendency already seen in the Entophysalidaceae might have been ancestral to the Pleurocapsales. Fritsch (1942, 1945), doubts such a derivation as there is no evidence of a prostrate filamentous condition in the juvenile stages of the Entophysalidaceae. Such a condition exists in the Pleurocapsales and it subsequently gives rise to the erect branches. Mitra (1951) recently described a new *Chlorogloea*, *C. fritschii*. The endospores of this alga on germination at first produces an uniseriate filament which by further division in different directions gives rise to a mature alga which resembles *Microcystis*. Mitra records very clearly the formation of a ' filamentous condition ' in the early stages of *Chlorogloea* thereby supporting Geitler's derivation of the Pleurocapsales from the Entophysalidaceae.

The Scytonemataceae might have been variously derived. It can be derived from a *Lyngbya*-like ancestor through *Plectonema* by the development of the heterocyst or from forms like *Nodularia* and *Aulosira*.

Rivulariaceae too shows affinities to more than one family. It can be derived from *Microchaete* by the development of an apical hair or might be evolved from the Scytonemataceae through such forms as *Tildenia* (*see* also Bornet and Flahault, 1887; Poljansky, 1928; Fritsch, 1942). The simpler Stigonemataceae can be derived from the simple Nostocales by the appearance of true branching. The affinities of the Mastigocladopsidaceae is not clear.

The author in general accepts Fritsch's classification (*see* also Papenfuss, 1955) though he departs from the same in a few points. Fritsch (1944, p. 265; 1945, p. 846) suggests retention of the genus *Mastigocladus* in the Stigonemataceae and the separation of *Brachytrichia* into a separate family. This he does owing to the fact that *Mastigocladus* exhibits occasionally true branching (Frémy, 1936; also Hansgirg, 1885). Similar undoubted true branches are known in *Brachytrichia* also (Iyengar and De ikachary, 1954) and the branching in the two genera has a more or less similar origin by the oblique division of a single parent cell. Further reverse ' v '-shaped branching is essentially a true branching and these genera should be included in the Stigonematales but in a distinct family, Mastigocladaceae (Iyengar and Desikachary 1954. *see* also Setchell and Gardner, 1919; Drouet, 1951; Schmidt, 1955). The genera *Richelia* and *Raphidiopsis* are placed in the Nostocaceae (*see* Geitler, 1942).

In placing the Diplonemataceae in the Stigonematales the writer follows Borzi (1914). These members have undoubted true branching and the presence of abundant false branching does not minimise the importance of the presence of the former. In fact, false branching is present in varying degrees in *Hapalosiphon* spp.

The following is the synoptic arrangement of the families and Orders as followed in the present work.

Phylum CYANOPHYTA Smith (1938).
  Class Cyanophyceae Sachs (1874, 248).

    Order CHROOCOCCALES Wettstein (1924, 79).
      Fam. Chroococcaceae Nägeli (1849, 40).
      Fam. Entophysalidaceae Geitler (1925b, 235).

    Order CHAMAESIPHONALES Wettstein (1924, 79).
      Fam. Cyanidiaceae Geitler (1933).
      Fam. Chamesiphonaceae Borzi (1882, 298).
      Fam. Dermocarpaceae Geitler (1925b, 247).

    Order PLEUROCAPSALES Geitler (1925b, 232).
      Fam. Pleurocapsaceae Geitler (1925b, 238).
      Fam. Hyellaceae Borzi (1914, 359).

    Order NOSTOCALES Geitler (1925b, 252).
      Fam. Oscillatoriaceae (S. F. Gray) Dumortier ex Kirchner (1898, 61).
      Fam. Gomontiellaceae Elenkin (1936, 543).
      Fam. Nostocaceae Kützing (1843, 203).
      Fam. Scytonemataceae Rabenhorst ex Born. and Flah. (1887, 81).
      Fam. Microchaetaceae Lemmermann (1907, 101).
      Fam. Rivulariaceae Rabenhorst (1868, 200).

Order STIGONEMATALES Geitler (1925b, 252).

- Fam. Capsosiraceae Geitler (1925b, 255).
- Fam. Pulvinulariaceae Geitler (1925b, 254).
- Fam. Nostochopsidaceae Geitler (1925b, 257).
- Fam. Diplonemataceae (Borzi) Elenkin (1934, p. 79).
- Fam.' Mastigocladaceae Geitler (1925b, 263).
- Fam. Mastigocladopsidaceae Iyengar and Desikachary (1946, 58).
- Fam. Stigonemataceae Kirchner (1898, 80).

# CYANOPHYTA

## PART II

## SYSTEMATIC PART

# BLUE-GREEN ALGAL FLORA OF INDIA

## INTRODUCTION

In 1849 Montagne described the first blue-green alga from India, *Calothrix indica* from Assam. Since then, the Indian blue-green algae have appeared in as many as 180 publications. This number may not mean much. But looking at the number of species reported and the relative percentage to the world flora one must feel a good deal has been worked out and it is just time to take stock of the present knowledge to enable us to plan future investigations.

So far 85 genera and about 750 species have been reported from India and its neighbourhood. Of these about 170 species have been reported for the first time from India and represents about 22 per cent of the Indian flora. Of the rest 580 species about 100 species are cosmopolitan and 45 species are also probably cosmopolitan, making in all a total of about 20 per cent of the flora. About 31 per cent of the flora is known from different parts of Africa, and a similar percentage from England and different parts of Europe. Probably the largest percentage may be said to be known from the Asiatic continent including Russia. A good percentage of the Indian blue-green algae is represented in the Russian flora. The World population may be said to reach 160 genera and 1,500 species. The Indian flora is nearly 50 per cent of the genera as well as the species.

In reviewing the flora one remembers the various algologists who have notably contributed to this knowledge. In the last century Kurz has probably contributed the largest to our knowledge of the Indian and the Burmese algae. Kurz's specimens were worked out by Zeller and Martens and form the matter of nearly half dozen publications (Krempelhuber, 1869; Martens, 1870a, 1870b, 1871a, 1871b; Zeller, 1873a, 1873b). Much of the material was distributed to the European herbaria and also included in some of the Exsiccata issued by European algologists, such as Rabenhorst, Wittrock etc.

The next largest contribution came at the turn of the century. Hansgirg made a large collection of algae from India especially in the vicinity of Bombay and Poona. These have been worked out by Schmidle (1900a, 1900b) and Beck and Zahlbruchner (1897). Turner has recorded some blue-green algae from India (1892) and the Wests from India (1907) and Ceylon (1902).

Ferguson's and Harvey's collections of blue-green algae from Ceylon have found their way into European herbaria and have been included by Bornet and Flahault (1886–1888) and Gomont (1892) in their revisions of the Hormogonales.

Fritsch visited Ceylon in the beginning of the century and studied the freshwater and subaerial algae of Ceylon. His papers (1907a, 1907b) and those of Lemmermann (1907), Wille (1915), Crow (1923a, 1923b) and of Holsinger (1935, 1955) are the major sources of information on the Ceylon flora. Some of Fritsch's collections representing the genera *Scytonema* and *Tolypothrix* have been studied by Bharadwaja (1934).

It is probably not till 1920 that any major attempt was made by the Indians themselves in the study of Algae. Though Kirtikar (1886) was the first Indian to record any alga, yet not much was done by the way of a serious study of these forms till 1919, when Ghose published his first paper on the blue-green algae. Ghose in a series of publications (1919, 1923; 1926; 1927a-e, 1931) has vastly contributed to our knowledge of the Indian blue-green algae especially of the Punjab and more so of Burma, and the neighbouring islands. Next stage in the working out of the Burmese flora was the appearance of Skuja's excellent work (1949) on the freshwater algae of Burma based on Prof. Khanna's collections. Drouet (1938) also has recorded a new *Arthrospira* from Burma.

Bharadwaja in 1928 began a series of studies on the Indian blue-green algae. His studies in the genera *Scytonema* and *Tolypothrix* based on his own collections and to a larger extent on those of Prof. Iyengar and Prof. Fritsch and his contribution on the mode of branching in these genera stand foremost (*see* Bharadwaja, 1933, 1934). He (1935) and his students (Singh, R. N., 1939a, b; 1942a, c; Singh, V. P., 1941; Rao, C. B., 1935, 1936, 1937a, b, 1938a, b, 1947; Rao, C. S., 1939, 1940; Parukutty, 1939, 1940) have contributed to furtherance of our knowledge of the flora of India especially of the many parts of northern India. Dixit (1936) published an account of the blue-green algae of Bombay and further additions have been made by Gonzalves and Joshi (1943a, b) and Gonzalves and Gangla (1949).

Bruhl and Biswas (1922a, b, 1924, 1926) and Biswas (1924, 1925, 1926, 1930, 1932, 1934) added considerably to our knowledge of the freshwater blue-green algae of Bengal and Assam. Banerji (1936, 1938) has described a number of blue-green algae from Calcutta and its neighbourhood.

Iyengar, and his students have studied the blue-green algae of South India. Ramanathan's work (1938) on *Anabaenopsis arnoldii* v. *indica*, Janet's study of *Westiellopsis* (1941), publications by Iyengar and Desikachary (1944, 1946a, b, 1953, 1954) and Desikachary (1945, 1946a, 1946b, 1948, 1953) have extended our knowledge of the blue-green algal flora of South India. Rao, C. B. (1938a) published an account of a good number of blue-green algae of Andhra Pradesh and together with that of Ghousuddin (1936) and Rao, K. V. N. (1956) are the only ones dealing with algal flora of that State. Frémy (1927/1928, 1931, 1942) published an account of the blue-green algae sent to him by Foreau from Shembaganur near Bombay. According to him there is a great similarity or affinity between the flora of the French equatorial Africa and the Indian flora.

While our knowledge of the freshwater flora of India has advanced fairly well, our knowledge of the Marine blue-green algae has not progressed. Except for the publications of Boergesen (1935, 1936), Iyengar and Desikachary (1944), and Venkataraman (1957) there has not been any great effort at studying these forms.

In thus reviewing, many gaps in our knowledge come to light. Morphological studies and physiological studies have not received the same attention. India abounds in thermal waters. Kirtikar recorded the first thermal alga in 1886 and since then only a few papers have been published on these algae (Drouet, 1938; Gonzalves, 1946, 1947), and intensive investigations of the thermal flora on the pattern of Copeland (1936) and other workers is needed. Many of the species described as new from India by Zeller still remain as " Species inquirendae." A search for the original material and a restudy of them is called for.

While it is true that our knowledge of the blue-green algal flora of India has advanced more than similar efforts in the other groups yet it is nonetheless true that attention must be focussed in future on the physiology, ecology and last but not least on the morphology and cytology of the blue-green algae.

# CYANOPHYTA

## Class CYANOPHYCEAE Sachs

(Lehrb. d. Botanik, 4 Aufl., 1874.)

*Myxophyceae* Wallr., Fl. Crypto. German. 4, 1833.

*Schizophyceae* Cohn, Jahreb. Schles. Ges. f. Vaterla. Cultur, 1879.

Unicellular or multicellular algae without a true nucleus or chromatophore. Protoplast differentiated into peripheral zone with photosynthetic pigment (chromatoplasm) and a central colorless portion with a generative function (centroplasm), and assimilation pigments chlorophyll, phycocyanin, phycoerythrin, carotinoids ; contents blue-green, olive-green, yellowish, rose, violet seldom yellow-green, green or yellowish brown, never really chlorophyll green or real brown coloration seen. Cell wall thin or after gelatinization very thick, colorless, or often yellow to brown, seldom red, blue or violet colored. Photosynthetic product glycogen or glycosides, starch absent. Reproduction by division or through endospores, exospores, hormogones, planococci, seldom through the heterocysts, fragmentation of the thallus and also of the trichome into parts or individual cells (hormogones), spores or pseudohormogonia (hormocysts). Motile flagellated stages absent. Sexual reproduction not known or absent.

The number of orders distinguished has been changing with different authors (see under *classification*). Some (Geitler, 1942; Frémy, 1929, 1932) recognise three to four orders, Chroococcales, Chamaesiphonales (or Dermocarpales and Pleurocapsales) and Hormogonales. Fritsch (1944) stressed on the importance of heterotrichous organisation of the thallus and allied members. He recognised Pleurocapsales and supported the separation of the Nostocales from the Stigonematales as was originally suggested by Geitler (1925b) and did not favour the order Hormogonales.

### KEY TO THE ORDERS.

The class is divided into five orders:

1. Plant unicellular or colonial, sometimes forming a pseudofilamentous colony, never with a " trichome organisation," no differentiation into base and apex, endospores not formed in sporangia; no exospores; nannocytes present.................... *Chroococcales* (p. 78).

2. Plant unicellular, attached, typically differentiated into base and apex, reproduction by endospores or exospores................................. *Chamaesiphonales* (p. 166).

3. Plant more or less distinctly filamentous, attached, arrangement very uniform, chroococcaceous structure, often forming parenchymatous thalli with prostrate and erect

filaments, without differentiation into trichome and filament, no hormogones, no heterocysts, endospores in sporangia........................................*Pleurocapsales* (p. 177).

4. Plants filamentous, with trichome and filament organised or 'hormogonalen organisation', hormogones present, often with heterocysts, akinetes, exospores, or endospores, pseudo-hormogonia present.
    a. Without true branching, unbranched or with false branching . . . *Nostocales* (p. 185).
    b. With true branching, or dichotomous branching, and often with heterotrichous condition, i.e., with a differentiation of prostrate and erect portions. *Stigonematales* (p. 565).

## Order CHROOCOCCALES Wettstein

Handb. Syst. Botanik, 3, Aufl., 79, 1923; *non* Geitler, Synopt. Darst. Cyano., Beih. bot. Centralbl., 41 (abt. 2): 223, 1925; *nec* Elenkin, Monogr. Alg. Cyan. URSS, 539, 1936.

The order is divided into two families.

### KEY TO THE FAMILIES

1. Cells unicellular or forming colonies, not forming filament-like growth *Chroococcaceae* (p. 78).
2. Cells of thallus arranged in a linear series forming pseudofilamentous growth *Entophysalidaceae* (p. 159).

## Family CHROOCOCCACEAE Nägeli

Gatt. einzell. Algen, 44, 1848; em. Geitler, Beih. bot. Centralbl., 41 (abt. 2): 223, 1925.

Cells mostly spherical, ellipsoidal, cylindrical, seldom spindle shaped, single or forming colonies; membrane thick, mucilaginous, often lamellated, with an overall formation of amorphous mucilaginous masses; colony shapeless, spherical, ellipsoidal, tabular or hemispherical; cell-division in two or three directions, in elongate cells often only in one direction—transverse, cells of many generations in a single parent sheath; multiplication by division, sometimes through nannocytes, spores with firm membranes present in some genera, also planococci.

The variation among the members is so great and the criteria used for the separation of genera and families are not so constant that the demarcation and further division of the chroococcaceous members varies very greatly between the two extremes known to taxonomist (*see* Papenfuss, 1955).

Many authors have suggested changes in the number of genera belonging to this order. Elenkin (1923, *see* also 1938) recognises only fourteen genera and reduces others as subgenera by suitably amending the different genera.—

1. *Microcystis* (Kütz.) Elenk. with three subgenera.—(a) *Eucoccochloris* (Kirchn.) Elenkin (*Aphanothece* Näg., *Coccochloris* Sprengel; *Aphanocapsa* Näg. *pro min. p.*); (b) *Capsothece* Elenk. (*Aphanocapsa* Näg., and *Aphanothece* Näg. *pro mai. p.*); and (c) *Eumicrocystis* Elenk. (*Microcystis* Kütz., *Anacystis* Menegh., *Polycystis* Kütz., *Clathrocystis* Henfr., and *Planosphaerula* Borzi.), 2. *Gomphosphaeria* (Kütz.) Elenk. with two subgenera.—(a) *Eugomphosphaeria* Elenk. and (b) *Coelosphaerium* (Näg.) Elenk., 3. *Coelosphaeriopsis* Lemm., 4. *Pilgeria* Schmidle, 5. *Chroococcus* (Näg.) Elenkin with four subgenera.—(a) *Euchroococcus* Elenk., (b) *Eucapsis* (Clements et Shantz) Elenk., (c) *Hydrococcus* (Kütz.) Elenk. (incl. *Oncobyrsa* Ag.), (d) *Chlorogloea* (Wille) Elenk., 6. *Gloeocapsa* (Kütz.) Elenk. with 6 subgenera.—(a) *Eugloeocapsa* Elenk., (b) *Entophysalis* (Kütz.) Elenk., (c) *Placoma* (Schousb.) Elenk., (d) *Chondrocystis* (Lemm.) Elenk., (e) *Gloeothece* (Näg.) Elenk., and (f) *Rhobdoderma* (Schm. et Lauterb.) Elenk.,, 7. *Synechococcus* (Näg.) Elenk., with two subgenera, (a) *Synechocystis* (Sauv.) Elenk. and *Eusynechococcus* (Näg.) Elenk., 8. *Bacularia* Borzi, 9. *Dactylococcopsis* Hansg., 10. *Myxobactron* Schmidle, 11. *Spirulina* Turp., 12. *Merismopedium* Meyen, 13. *Tetrapedium* Reinsch and 14. *Holopedium* (Lagerh.) Elenk., with three subgenera (a) *Coccopedium* (Troitzk.) Elenk., (b) *Euholopedium* Forti and (c) *Microcrocis* (Richt.) Forti.

Later Elenkin (Über neue Famil. Cyanoph., Acta Institut. Botan. Acad. Scient., URSS., Ser. 2, fasc. 1, pp. 17–21, also. Sovietskaia Botanica, 2(5): 51–84, 1934 and in Monogr. Algar. Cyano., pars spec., 1: 15–32, 1938) revised his ideas and recognised the different genera which he had reduced earlier to the rank of subgenera. He divides the Chroococcales into ten families—Coccobactreaceae Elenkin with 8 genera (*Synechocystis, Planosphaerula, Synechococcus, Catella, Rhabdoderma, Dactylococcopsis, Chroostipes* and *Cyanarcus*), Holopediaceae (*Coccopedia* and *Holopedia*), Beckiaceae Elenkin (*Beckia*), Merismopediaceae Elenkin (*Merismopedia* and *Pseudoholopedia*), Tetrapediaceae Elenkin (*Tetrapedia*), Microcystidaceae Elenkin (*Cyanodictyon, Microcystis* incl. *Aphanocapsa, Aphanothece, Dzensia*), Gloeocapsaceae Elenkin and Hollerb. (*Gloeocapsa* incl. *Chroococcus, Gloeothece, Eucapsis*), Coelosphaeriaceae Elenkin (*Coelosphaerium, Lemmermannia, Marssoniella*), Gomphosphaeriaceae Elenkin (*Gomphosphaeria, Snowella*) and Woronichiniaceae Elenkin (*Woronichinia*). In this he differs from Geitler (1932) in (1) including *Aphanocapsa* under *Microcystis,* (2) including *Chroococcus* under *Gloeocapsa,* (3) including all species of *Microcystis* with cylindrical cells under *Aphanothece,* (4) in placing *Coelosphaerium roseum* in a new genus *Snowella* and (5) lastly in creating a number of new families.

Drouet and Daily (1942, 1951, 1952, 1956) in a series of publications sought to delimit the different genera. They studied almost all the available type material and ultimately (1956) recognised a much smaller number of genera. They recognised only six genera and included the rest under them.

(1) *Coccochloris* Sprengel, (incl. *Synechococcus* Näg., *Gloeothece* Näg., *Gloeocapsa* sections *Rhodocapsa* Hansg., and *Xanthocapsa* Näg., *Aphanothece* Näg.,

*Rhabdoderma* Schmidle and Lauterborn, *Bacularia* Borzi, *Rhabdogloea* Schröder, *Spirillopsis* Naumann, *Cyanocloster* Kufferath, *Krkia* Pevalek, *Dzensia* Woronichin, and *Tetrarcus* Skuja); (2) *Anacystis* (incl. *Pleurococcus* Menegh., *Gloeocapsa* Kütz., *Sorospora* Hass., *Microcystis* subdiv. *Polycystis* Kütz., *Diplocystis* Trevisan, *Clathrocystis* Henfrey, *Cagniardia* Trevisan, *Chroococcus* Näg., *Monocapsa*, Itzigsohn, *Rhodococcus* section *Rhodocapsa* Hansgirg, *Eucapsis* Clements and Shantz, *Endospora* Gardner, *Chroococcidiopsis* Geitler, *Radiocystis* Skuja, *Aplococcus* Roze, *Gloeocapsa* section *Cyanocapsa, Coelosphaeriopsis* Lemm., *Planosphaerula* Borzi, *Myxosarcina* Printz and *Sphaerodictyon* Geitler), (3) *Johannesbaptistia* De Toni, J., (4) *Agmenellum* de Bréb., (incl. *Gonidium* Ehrenb., *Merismopedia* Kütz., *Holopedium* subgenus *Euholopedium* Forti, *Coccopedia* Troitzkaja, *Pseudoholopedia* Elenkin), (5) *Microcrocis* Richter, and (6) *Gomphosphaeria* Kütz. (incl. *Coelocystis* Näg., *Coelosphaerium* Näg., *Thamniastrum* Reinsch, *Marssoniella* Lemm., *Woronichinia* Elenkin and *Snowella* Elenkin). *Entophysalis* (including in itself *Hydrococcus* Kütz , *Exococcus* Näg., *Thaumaleocystis* Trevisan, *Dermocarpa* Crouan and others, in all about 42 genera otherwise included in the Chamaesiphonales of Geitler) is included in the family Chamaesiphonaceae of Borzi. Geitler (1932) recognised about 23 genera. In 1942, he retained most of these except that *Pilgeria, Planosphaerula* and *Tetrapedia* are eliminated. He includes *Woronichinia,* Elenk., *Lemmermanniella* (= *Lemmermannia* Elenkin *non* Chodat.), *Coelomoron* Buell., and *Tetrarcus* Skuja as valid genera.

The general classification recommended by Fritsch (1944, 1945) seems to be right and as such the separation of the forms showing a differentiation of base and apex is followed. Most of the Indian genera described herein seem to have distinct characters of their own that they merit retention. One has to only turn to the Chlorococcales for finding parallels in organisation and distinction of the unicellular and colonial members based on characters of the gelatinous matrix. Only two genera are eliminated from the family. The genus *Woronichinia* is not considered sufficiently distinct from *Coelosphaerium* (*see* p. 146). The genus *Tetrapedia* Reinsch is represented in India by four species, *T. foliacea* Turner from Bengal (Turner, 1892, p. 12), *T. gothica* Reinsch from N. India (Turner, 1892, p. 12), *T. reinschiana* Arch. from Burma (West and West, 1907, p. 242) and *T. wallichiana* Turner (1892, p. 12) from Bengal. Geitler (1942, p. 67–69) deletes this genus, since most of the species have been identified as developmental stages of green algae or as desmids and a few that have not been yet definitely redetermined have been left out owing to lack of complete knowledge regarding them. These species have not been recorded in India a second time.

Fourteen genera are known from the region.

## KEY TO THE GENERA

1. Cells single, or a few together, in a shapeless colony .......................... 2
1. Cells generally many in a single colony .......................... 8
    2. Cells spherical .......................... 3
    2. Cells elongate .......................... 5

3. Without individual mucilage envelopes .................... *Synechocystis* (p. 144)
3. With a distinct envelope .................................... 4
   4. Sheath vesicular .................................... *Gloeocapsa* (p. 111)
   4. Sheath not vesicular .................................... *Chroococcus* (p. 98)
5. Cell division transverse, with a firm vesicular sheath ............ *Gloeothece* (p. 124)
5. Cell division transverse, without such a sheath .................................... 6
   6. Cells ellipsoidal or cylindrical with round ends .......................... 7
   6. Cells with tapering ends, often forming spindle-shaped colonies *Dactylococcopsis* (p. 157)
7. Cells single, or 2–4 together, erect without a common mucilage *Synechococcus* (p. 143)
7. Cells bent, a few together in a common mucilage ............ *Rhabdoderma* (p. 145)
   8. Cells without any regular, or definite, arrangement .................... 9
   8. Cells with definite arrangement in distinct colonies .................... 14
9. Cells in a general amorphous mucilage, without or with a few distinct sheaths round the individual cells .................................... 10
9. Cells with distinct individual envelopes or sheaths, colonial mucilage not homogeneous .................................... 12
   10. Cells typically well packed into microscopic colonies of definite shapes, mostly planktonic .................................... *Microcystis* (p. 81)
   10. Cells loosely arranged, mostly not planktonic, forming macroscopic colonies .................................... 11
11. Cells spherical .................................... *Aphanocapsa* (p. 130)
11. Cells ellipsoidal to cylindrical .......................... *Aphanothece* (p. 136)
   12. Individual sheaths vesicular and broad, and formed one in another ...... 13
   12. Individual sheaths not vesicular, cells spherical ...... *Chroococcus* (p. 98)
13. Cells spherical .................................... *Gloeocapsa* (p. 111)
13. Cells ellipsoidal to cylindrical .......................... *Gloeothece* (p. 124)
   14. Colony with cells arranged in a tabular or cubical or three dimensional colony .................................... 15
   14. Colony a hollow sphere with cells arranged along the margin uniformly.... 16
15. Cells in regular transverse and longitudinal rows, tabular or flat colonies *Merismopedia* (p. 150)
15. Cells regularly arranged in three directions, in a cubical pattern .... *Eucapsis* (p. 157)
   16. Cells spherical, colonial mucilage homogeneous .... *Coelosphaerium* (p. 146)
   16. Cells pear-shaped, or nearly spherical, colonial mucilage not homogeneous, cells with distinct mucilage sheaths .............. *Gomphosphaeria* (p. 148)

## MICROCYSTIS Kützing

Linnaea: 8, 372 pp., 1833 em. Kützing, Tab. Phycologicae, 1:7, 1846; Species Algarum, 208, 1849; *non Microcystis* Elenkin in Not. Syst. Inst. Crypt. Horti. Bot. Petropol., 2: 67, 1923; *nec.*, Monogr. Alg. Cyan., 539, 1936; = *Anacystis* Meneghini, Consp. Algol. Eugan., 6, 1836; = *Clathrocystis* Henfrey, Micr. Journ., 53, 1856; = *Polycystis* Kütz., Tab. Phycologicae, 1: 7, 1846.

Cells spherical or elongated, many in spherical, ellipsoidal or irregularly overlapping or net-like colony, free-swimming, often with attached daughter colonies; cells in homogeneous colourless, often diffluent, mucilage, individual envelopes absent; cells mostly very densely arranged, cell-division in all directions, generally transverse in elongate cells; gas-vacuoles often present; nannocytes present in *M. flos-aquae*.

Since the beginning of the century a large amount of discussion has been going on on the delimitation or the validity of *Microcystis* spp. The criteria of separation are mainly the shape of the colony, nature of the colonial mucilage, and cell shape and size. Wesenburg-Lund (1904) studied the variation in *M. aeruginosa* and *M. flos-aquae* and suggested that the shape of the colony and the distinctness of the colonial mucilage could serve as criteria for the separation of the two genera (*see* also Teilung, 1941). Östenfeld (1904) studied similar variations in *Aeruginosa-flos-aquae-viridis*-complex. According to him these species are linked by a number of transitional forms and hence all the forms with pseudovacuoles are identical. Quite a number of workers have since then studied the same problem (Elenkin, 1924; Naumann, 1925; Nygaard, 1926). Crow, in 1923, studied the plankton species of *Microcystis* from Ceylon and distinguished 17 species. Geitler (1932) similarly distinguished 23 species of *Microcystis*. Drouet (1939) examined a large amount of material and distinguished only three species among the planktonic forms viz., *M. glauca*, *M. incerta* Lemm. (incl. *M. holsatica* Lemm., *M. pallida* Migula, *M. stagnalis* Lemm., *M. exigua* Zal.) and *M. aeruginosa* Kütz., (incl., *M. ichtyoblabe* Bréb., and of Kütz., *M. viridis* Lemm., *M. caerulea* Dickie, *Polycystis insignis* Beck., *M. prasina* Lemm., *M. flos-aquae* Kirchn., *apud* Lemm., *M. scripta* Lemm., *M. ochracea* Lemm., *M. robusta* (Clark) Nygaard, (= *Clathrocystis robusta* Clark), *M. protocystis* Crow, *M. pseudofilamentosa* Crow, *M. fusca* Zal., *M. angulata* Zal., *M. elabentoides* Zal., *M. floccosa* Zal., *M. globosa* Zal., and *M. ramosa* Bharadw.). He, however, eliminated 14 more species as either *Euglena* or other than blue-green algae. He listed 16 species as deserving a further inquiry. He suggested also separating the planktonic species of *Microcystis* into a separate genus, for which he prefers the name *Polycystis* Kütz. and transferring the other species to either *Aphanocapsa* or *Aphanothece* according to whether the cells are spherical or elongate. Recently Drouet and Daily (1956) have made a revision of the coccoid genera. In this they recognised *Anacystis* and *Coccochloris* and distributed all the known species of *Microcystis* among these two genera comprising eleven species. Thus it appears to be very difficult to delimit the species.

Elenkin (Monogr. Algar. Cyano., pars spec., 1: 95, 1938) included *Aphanocapsa* under *Microcystis* (Kütz.) Elenkin. He creates three sub-genera, *Eumicrocystis* Elenk., *Aphanocapsa* (Näg.) Elenkin and *Endobiotica* Elenk. *Eumicrocystis* included all the species of *Microcystis* with spherical cells, while the ones with oval or cylindrical cells were transferred to *Aphanothece* (Näg.) Elenk. He recognised *M. aeruginosa* (Kütz.) Elenk., *M. ichthyoblabe* Kütz., *M. firma* (Bréb. et Lenorm.) Schmidle, *M. pulverea* (Wood) Elenk. In *M. aeruginosa* he included a number of species as forms — f. *marginata* (Menegh.) Elenk. (= *M. marginata* Menegh.), f. *viridis* (A. Br.) Elenkin. (= *M. viridis* A. Br.), f. *protocystis* (Crow) Elenk. (= *M. protocystis* Crow), f. *sphaerodictyoides* Elenk. (Pl. 17, fig. 6), f. *aeruginosa* (Kütz.) Elenk (= f. *typica*; = *M. aeruginosa* Kütz.), f. *flos-aquae* (Wittr.) Elenk. (= *M. flos-aquae* Wittr.), f. *pseudofilamentosa* (Crow) Elenk. (= *M. pseudofilamentosa* Crow), f. *scripta* (Richter) Elenk. ( = *M. scripta* Richter) and f. *ochracea* (Brand) Elenk. ( = *Polycystis ochracea* Brand). Similarly *M. pulverea* includes f. *pulverea* (Wood) Elenkin ( = f. *typica*; = *M. pulverea* (Wood) Forti), f. *incerta* (Lemm.) Elenk. ( = *M. pulverea* var. *incerta* (Lemm.) Crow), f. *elongata* Crow, f. *stagnalis* (Lemm.) Elenkin (= *M. stagnalis* Lemm.), f. *holsatica* (Lemm.) Elenk. (= *M. holsatica* Lemm.), f. *minor* (Lemm.) Hollerb., (*M. holsatica* var. *minor* Lemm.), f. *parasitica* (Kütz.) Elenk. (= *M. parasitica* Kütz.) and includes also *Polycystis elongata* W. & G. S. West *Clathrocystis elongata* (W. & G. S. West) Forti, *M. minutissima* W. West, and a few species of *Aphanocapsa*.

Huber-Pestalozzi (Die Binnengewässer, 16(1): 132, 1938) includes *M. pseudofilamentosa, M. protocystis, M. scripta* and *M. ochracea* in *M. aeruginosa.*

Wesenberg-Lund and Crow are of the opinion that the shape of the colony and the limits of the colonial mucilage can be considered as criteria while Östenfeld and Drouet and Daily feel that these are not permanent characters. Preservation in formalin is said to affect the mucilage characters thus making it unsafe to depend upon the same for separation. However, it may be mentioned here, Crow, in 1923, worked out formalin material collected by Fritsch about the year 1904 in Ceylon and still he found that both *M. viridis* and *M. marginata* showed the distinct characteristics of their colonial mucilage. Similar has been the present author's experience. In some species, the distinct characters of the mucilage were not lost by preservation. *M. aeruginosa* to a lesser extent and *M. flos-aquae* to a greater extent are somewhat affected by preservation. It seems justifiable to follow the conventional method of keeping these two species separate until single cell isolations of what appears to be distinct species in the field are cultured in the laboratory so that their individual variations are known fully to enable one to definitely know whether both of them develop into the other species. It may be mentioned here that Teilung (Sv. Bot. Tidsskrift, 35(4) : 337–349, 1941) also thinks *M. flos-aquae* and *M. aeruginosa* as good species (*see* his comparison table and also *see* Holsinger, 1954).

Lund (Naturalist, London, 835: 143–148, 1950) observed the movement of individual cells in a number of *Microcystis* spp. He, however, reports the absence of any movement in *M. aeruginosa* and *M. flos-aquae*. Prof. Iyengar has observed the movement of individual cells in a *Microcystis robusta* from Red Hills Lake, Madras.

Altogether 19 species are reported from the region of which 17 are included here. Two species are eliminated, (1) *M. olivacea* Kütz. (= *Euglena, see* Drouet and Daily, 1956, p. 155) and (2) *Microcystis donnellii* Wolle which was reported from Lahore by Ghose (1924, p. 337) as occurring on submerged objects in stagnant rainwater pools. After examination of type material of *M. donnellii* Drouet and Daily (1956, 155) have identified it as a ciliate containing *Zoochlorella* sp.

Names such as *Polycystis* Kütz., and *Diplocystis* Ag., have been preferred for one reason or another (*see* Daily 1942; Smith 1951). Recently Komarek has gone into the problem of the nomenclature of " *Microcystis* " and has suggested conservation of the genus as *Microcystis* Kütz. ex Lemm. (1910) with *M. aeruginosa* as the type (*see* Taxon, 6(5); 145–149, 1957).* Drouet and Daily (1956) give *Microcystis noltii* Kütz. as the type species (cf. Forti in De Toni, 1907, p. 93).

## KEY TO THE SPECIES

1. In salt water ........ 1. *M. litoralis* (p. 85)  
1. In fresh water ........ 2  
  2. Cells spherical ........ 3  
  2. Cells elongate ........ 15  
3. Cells 6 – 9 μ broad ........ 2. *M. robusta* (p. 85)  
3. Cells mostly 3 – 7 μ broad ........ 4  
  4. Cells with gas-vacuoles ........ 5  
  4. Cells without gas-vacuoles ........ 13  
5. Margins of colonial mucilage thick, refractive, lamellated ........ 6  
5. Margins of colonial mucilage diffluent ........ 9  
  6. Colonies round or nearly so ........ 7  
  6. Colonies elongate, many times longer ........ 8  
7. Colonies compound with daughter colonies ........ 3. *M. viridis* (p. 87)  
7. Colonies simple ........ 4. *M. marginata* (p. 87)  
  8. Colonies compound with partial colonies ...... 5. *M. bengalensis* (p. 89)  
  8. Colonies simple without partial colonies, cells uniformly distributed, clathrate ........ 6. *M. elongata* (p. 89)  
9. Colonies with cells closely arranged ........ 10  
9. Cells loosely arranged, mucilage highly diffluent ........ 7. *M. protocystis* (p. 91)  
  10. Colonies round or sometimes elongate but not many times longer than broad ........ 11  
  10. Colonies lenticular or lamellate ........ 8. *M. lamelliformis* (p. 91)  
  10. Colonies not greatly lobed, many times longer than broad ........ 12  
  10. Colonies like cuneiform figures ........ 9. *M. scripta* (p. 91)  
11. Colony clathrate ........ 10. *M. aeruginosa* (p. 93)  
11. Colony not clathrate ........ 11. *M. flos-aquae* (p. 94)  
  12. Colony reticulate, with partial colonies, cells 3–7 μ br. 12. *M. pseudofilamentosa* (p. 94)  
  12. Colony not reticulate, without partial colonies, cells 3–5 μ br. 13. *M. ramosa* (p. 95)

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* This is a good suggestion. Excepting the Hormogonales, the blue-green algae have no special starting point dates. Owing to the great amount of confusion existing in the taxonomy of the coccoid members Lemmermann's Kryptogamenflora der Mark Brandenburg, 3, 1910, should be, I propose, the starting point for genera other than those covered by Gomont (1892) and Bornet and Flahault (1886-1888). — T. V. Desikachary.

13. Colony much longer than broad .................... 14. *M. stagnalis* (p. 95)
13. Colony little longer than broad .................................................. 14
 14. Free-swimming, clathrate, cells up to 1 μ broad .... 15. *M. holsatica* (p. 96)
 14. Free-swimming or attached, not clathrate, with distinct colonial mucilage.................................. 16. *M. pulverea* (p. 96)
15. Cells 0.8–1 μ br. .................................. 17. *M. orissica* (p. 97)
15. Cells 2–4.5 μ br. .................................. 18. *M. elabens* (p. 97)

### 1. **Microcystis litoralis** (Hansg.) Forti

in De Toni, Sylloge Algarum, 5: 89, 1907; Geitler, Kryptogamenflora, 134, 1932; Frémy, Cyano. cotes d'Eur., 11, 1933.

= *Polycystis litoralis* Hansgirg in Foslie Marine Algae, Norway, 169, pl. 3, fig. 13, 1890.

= *Coccochloris aeruginosa* (Näg.) Drouet and Daily, Butler Univ. Studies, 222, 1952 (p.p.).

Colony round, ellipsoidal or irregularly arranged, often with thick gelatinized colonial mucilage, 30–60μ sometimes up to 210 μ broad, up to twice as long as broad, cells spherical or ellipsoidal, 3–5 μ broad, up to twice as long as broad, closely arranged, pale blue-green, without gas-vacuoles.

Ghose (1924, 336) has described this species from tanks (?) in Shalimar gardens, Lahore, forming dirty green floating masses (cells 3 μ broad and 5–7 μ long). This alga was originally described from saltwater lagoons along with *Ectocarpus* and *Cladophora* in Finland, Norway.

### 2. **Microcystis robusta** (Clark) Nygaard

in Ostenfeld and Nygaard Phytophankton Gatun Lake, Panama-Kanal, Dansk Bot. Ark., 4(10): 8, figs. 1–4, 1925; Geitler, Kryptogamenflora, 135, fig. 58, 1932.

= *M. flos-aquae* var. *robusta* Nygaard, K. Danske Videnskab. Selsk. Skr., 7(1): 185, 1949.

= *Anacystis cyanea* (Kütz.) Drouet and Daily, Butler Univ. Stud., 10: 221, 1925; Rev. Coccoid Myxophyceae, 36, 1956 (p.p.).

= *Clathrocystis robusta* Clark, Holophyt. Plankton lakes Atitlan and Amatitlan, Guatemala, Proc. Biol. Soc., Washington, 2: 94, 1909.

Pl. 17, Figs. 7–10

Colonies at first round, later irregularly elongate and clathrate; sheath distinct, later gelatinising; cells 6–9 μ diam., spherical, without gas-vacuoles.

Planktonic in standing waters, Calcutta (Biswas, 1927, 51; Banerji, 1936, 295); Madras (Ganapathi, 1940a, 246); Malayan lakes (Nygaard, 1926).

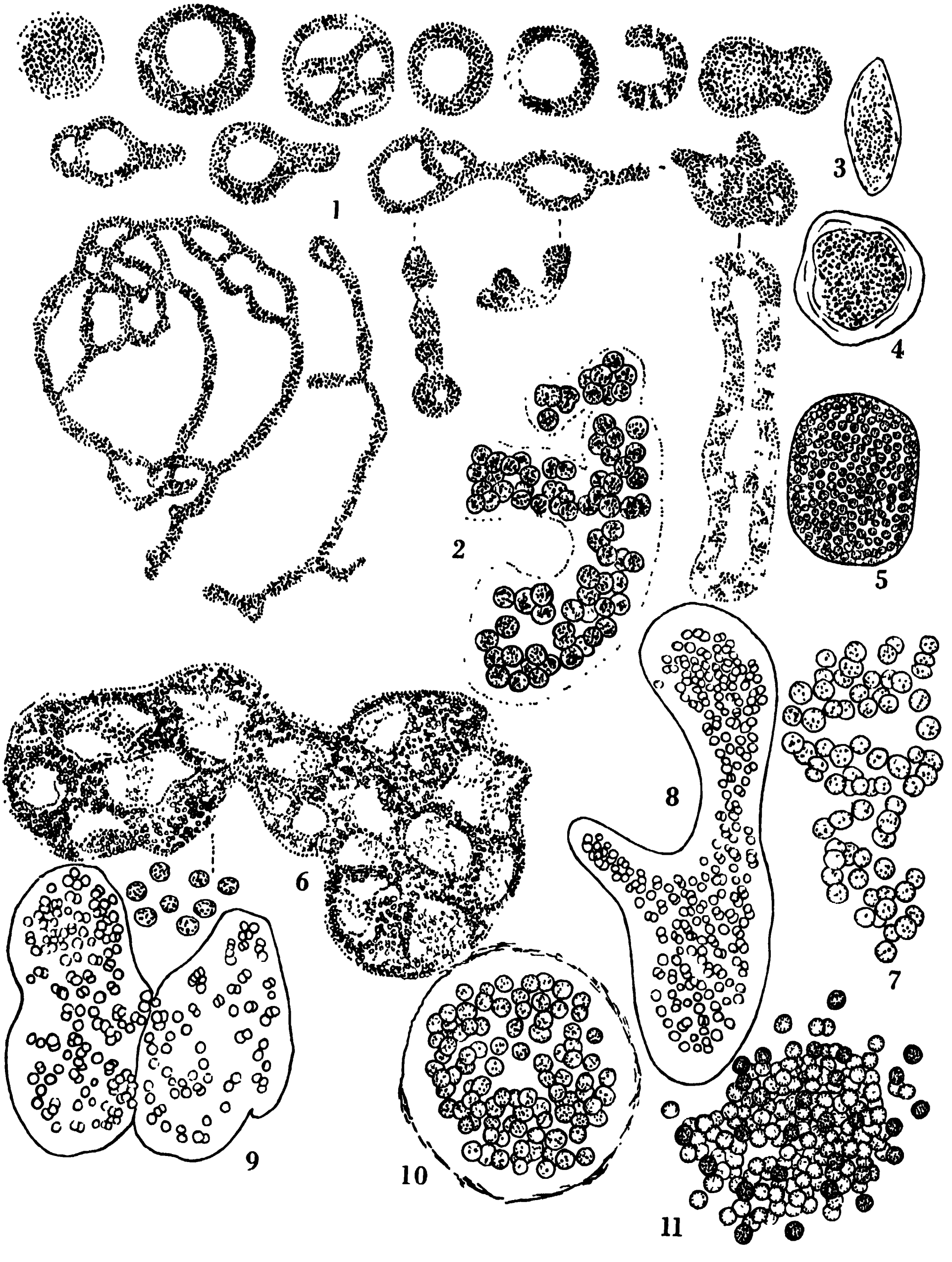

PLATE 17, Figs. 1–11.

1. *Microcystis aeruginosa* Kutz., colonies (after Huber-Pestalozzi); 2. *M. aeruginosa* v. *major* (Wittr.) Smith (after Smith); 3–5. *M. marginata* (Menegh.) Kutz. (3 after West and 4, 5 after Crow); 6. *M. aeruginosa* f. *sphaerodictyoides* Elenkin (after Elenkin); 7–10. *M. robusta* (Clark) Nygaard (after Nygaard); 11. *M. flos-aquae* (Wittr.) Kirchn. (after Smith).

### 3. **Microcystis viridis** (A. Br.) Lemm.

Zeitschr. für fischerie, 11: 101, 1903; Abh. Nat. Ver. Bremen, 17: 342, 1902; Forti in De Toni, Sylloge Algarum, 5: 90, 1907; Lemmermann, Kryptogamenflora der Mark Brandenburg, 3: 74, 1910; Crow, Tax. gen. *Microcystis,* New Phytol. 22: 65, 1923a; Frémy, Myxo. d'Afr. équat. franc., 18, fig. 13, 1929; Geitler, Kryptogamenflora, 135, 1932; Frémy, Cyano. cotes d'Eur., 10, pl. 1, fig. 8, 1933.

= *M. aeruginosa* f. *viridis* (A. Br.) Elenkin, Monogr. Algar. Cyano., pars spec., 1: 106, 1938.

= *Anacystis cyanea* (Kütz.) Drouet and Daily, Butler Univ. Bot. Stud., 10: 221, 1952; Rev. Coccoid Myxophyceae, 36, 1956 (p.p.).

Pl. 18, Figs. 1–6

Colonies round or rectangular, consisting of a large number of partial or daughter colonies surrounded by a common mucilaginous sheath, margins of colonial mucilage definite and highly refractive; cells 3–7 μ in diam., spherical with gas-vacuoles.

Planktonic.—Tank Nuwarawewa at Anuradhapura in Ceylon (Crow, 1923a, 65; 1923b, 139); Calcutta (Banerji, 1936, 293); Trivandrum and Madras (!) in India; in various lakes, Rangoon in Burma (Skuja, 1949, 15).

Single cells often develop a thick envelope of mucilage all round and break away from the thallus. These cells later on by further division give rise to new colonies.

### 4. **Microcystis marginata** (Menegh.) Kütz.

Tab. Phycologicae, 1: 6, pl. 8, 1845–49; Crow, Tax. gen. *Microcystis,* New Phytol., 22: 65, figs. g-h, 1923a; Frémy, Myxo. d'Afr. équat. franc. 18, fig. 14, 1929; Geitler, Kryptogamenflora, 137, fig. 59a-c, 1932.

= *Anacystis marginata* Menegh. Consp. Algol. Eugan., 324, 1837.

= *M. aeruginosa* f. *marginata* (Menegh.) Elenkin, Monogr. Algar. Cyano., pars spec., 1: 106, 1938.

= *Anacystis montana* f. *montana* Drouet and Daily, Rev. Coccoid Myxophyceae, 46, 1956 (p.p.).

Pl. 17, Figs. 3–5

Colony round or irregularly flattened and more or less lenticular, generally simple; margins of colonial mucilage very distinct, refractive, sometimes stratified; single colony ellipsoidal to ovoid in outline, 140–150 (-200) μ in length and 60–95 μ in width; cells 3–6 μ in diam., closely arranged, with gas-vacuoles.

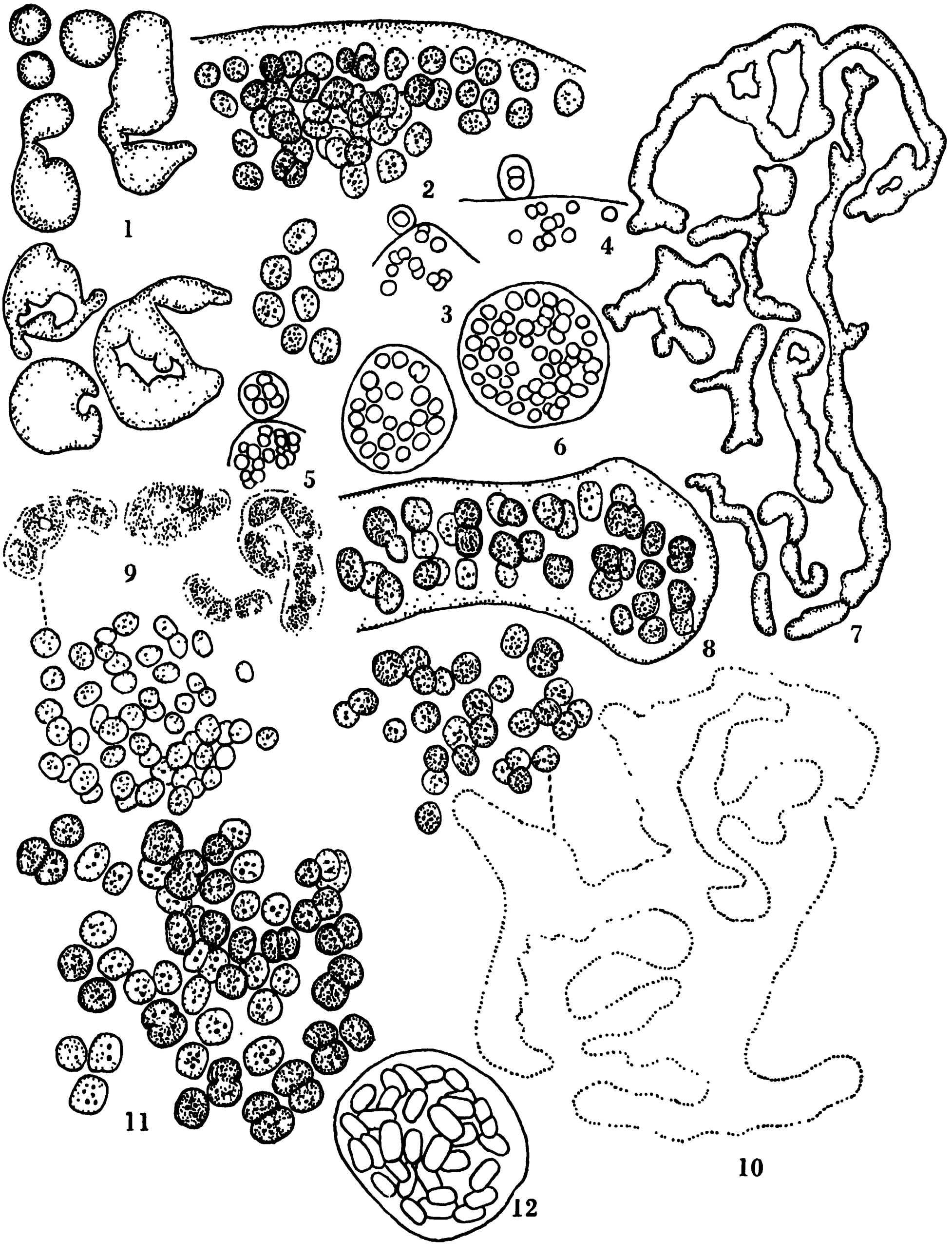

PLATE 18, Figs. 1–12.

1–6. *Microcystis viridis* (A. Br.) Lemm., 4–6, formation of new colonies; 7–8. *M. elongata* sp. nov.; 9. *M. pseudofilamentosa* Crow; 10. *M. aeruginosa* Kütz; 11. *M. flos-aquae* (Wittr.) Kirchn.; 12. *M. elabens* (Bréb.) Kütz. (all original).

Planktonic in Kalawewa, Nuwarawewa and Perithpanpokuna near Anuradhapura in Ceylon (Crow, 1923a, 65; 1923b, 139); planktonic in ponds, Calcutta (Banerji, 1936, 293) and in the river Hooghly (Biswas, 1942, 198); Sholavaram tank near Madras (Ganapathi, 1940a, 240) and on barks of trees, Calcutta (Bruhl and Biswas, 1923, 2).

Crow (1923a) draws attention to the great degree of resemblance between the young stages of this species and *M. viridis*. Wille (1925) based on an examination of original material of Meneghini describes the cells as cylindrical (2 μ br. × 2–4 μ long) (cf., Kützing's figures). Hence the two species are kept distinct.

### 5. **Microcystis bengalensis** Banerji

Myxo. of Lower Bengal, I, J. Indian bot. Soc., 15: 295, figs. 2A and B, 1936.

Pl. 19, Figs. 5, 6

Colonies irregularly branched long and broad, varying greatly in form and size, 30–280 μ broad and 120–800 μ long, of partial colonies which break off and divide again to form compound colonies; sheath thick stratified, often distinct; daughter colonies mostly elongated, irregularly branched like the parent, margins of colonial mucilage not distinct; cells spherical with gas-vacuoles, 3.5–6 μ diam.

Planktonic in a tank, Calcutta, Bengal.

In the characteristics of the mucilage the form comes near *M. viridis* and *M. marginata*, not in the shape of the colony. In the shape of the colony, the arrangement of cells and its dimensions it comes near *M. pseudofilamentosa.*

### 6. **Microcystis elongata** sp. nov.

Pl. 18, Figs. 7, 8

Colony elongate, sometimes clathrate, up to 1 mm. in length, unconstricted, colonial mucilage distinct, occasionally lamellated, hyaline, refractive; cells often closely arranged, grouping absent, arrangement not uniform, 3.9–5.2 μ broad, gas-vacuoles present.

Planktonic in a temple tank, Madras (!).

The species comes very near *M. viridis* and *M. marginata* in the colonial mucilage being distinct, but differs in being elongate and in the narrower cells. The alga resembles *M. pseudofilamentosa* in the linear colony, but differs in the colonial mucilage being distinct and in the absence of grouping of cells. It resembles similarly *M. bengalensis* Banerji in the habit and in the nature of the colonial mucilage but differs in the lack of grouping of cells into partial colonies, in the much elongate thallus and in not being commonly clathrate.

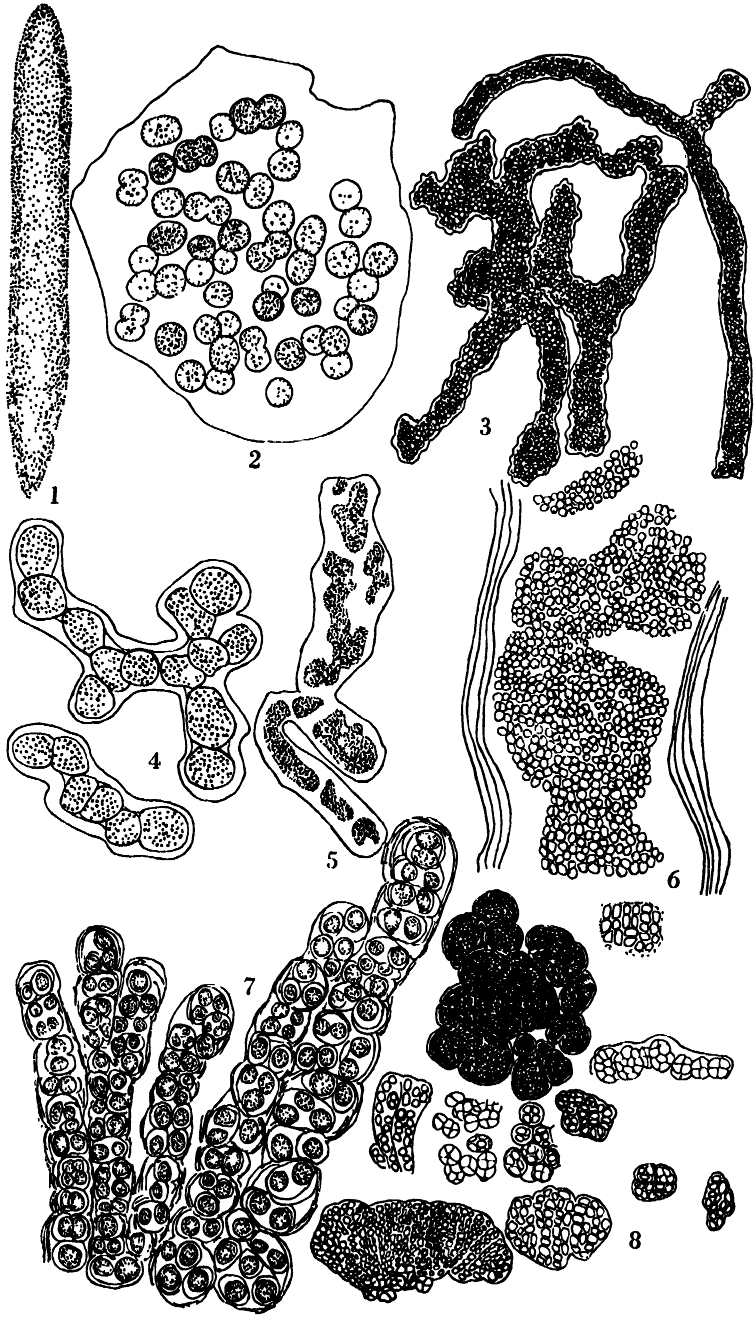

PLATE 19, Figs. 1–8.

1, 2. *Microcystis lamelliformis* Holsinger (after Holsinger); 3. *M. aeruginosa* var. *elongata* Rao, C. B. (after Rao, C. B.); 4. *M. ramosa* Bharadw. (after Bharadwaja); 5, 6. *M. bengalensis* Banerji (after Banerji); 7. *Entophysalis granulosa* Kütz. (after Frémy); 8. *Chlorogloea microcystoides* Geitler (after Geitler).

### 7. **Microcystis protocystis** Crow

Tax. gen. *Microcystis,* New Phytol., 22: 62, pl. 1, fig. d, 1923; Geitler, Kryptogamenflora, 140, fig. 62b, 1932.

= *M. aeruginosa* f. *protocystis* (Crow) Elenk., Monogr. Algar. Cyano., pars spec., 1 : 106, 1938.

= *Anacystis cyanea* (Kütz.) Drouet & Daily, Butler Univ. Bot. Stud. 10: 221, 1952; Rev. Coccoid Myxophyceae, 36, 1956 (p.p.).

Pl. 20, Fig. 4

Colonies irregular, often diffuse, with limits of colonial mucilage not clearly delimited, sometimes disappearing (!) ; cells very numerous, varying in the mode of aggregation from closely packed to generally dissociated, spherical, 3.5–6.5 μ diam., with gas-vacuoles.

Planktonic forming a water bloom in a tank, Andakulam, near Trincomalie and rock pools connected with Perithpanpokuna near Anuradhapura in Ceylon (Crow, 1923a, 62; 1923b, 139); planktonic in stagnant ponds or lakes, Sholavaram lake near Madras (Ganapathi, 1941a, 240) ; Calcutta (Banerji, 1936, 294) and in a puddle of receding Ganges water near Allahabad (Gupta, 1956, 76).

### 8. **Microcystis lamelliformis** Holsinger

The Plankton algae of three Ceylon lakes, Hydrobiologia, 7: 15, fig. 3, 1954.

Pl. 19, Figs. 1, 2

Colonies free-floating, spherical or irregular when very young, lamellate or lenticular when older and attaining macroscopic size, mucilage envelope wide or not extending beyond the cell mass; cells spherical, 3-4 μ diam., loosely aggregated, cell sheath well marked; pseudovacuoles numerous, small and more or less rounded.

In plankton, Beira Lake, Nuwarawewa tank, and Lake Gregory in Ceylon (Holsinger *loc. cit*).

### 9. **Microcystis scripta** (Richter) Lemm.

Zeitschr. für Fischerie, 11 : 101, 1903; Forti in De Toni, Sylloge Algarum, 5: 88, 1907; Geitler, Kryptogamenflora, 139, fig. 62a, 1932.

= *Polycystis scripta* Richter, Hedwigia, 25: 255, 1886.

= *M. aeruginosa* f. *scripta* (Richter) Elenkin, Monogr. Algar. Cyano., pars spec., 1 : 103, 1938.

= *Anacystis cyanea* (Kütz.) Drouet & Daily, Butler Univ. Bot. Stud., 10: 221, 1952; Rev. Coccoid Myxophyceae, 36, 1956 (p.p.).

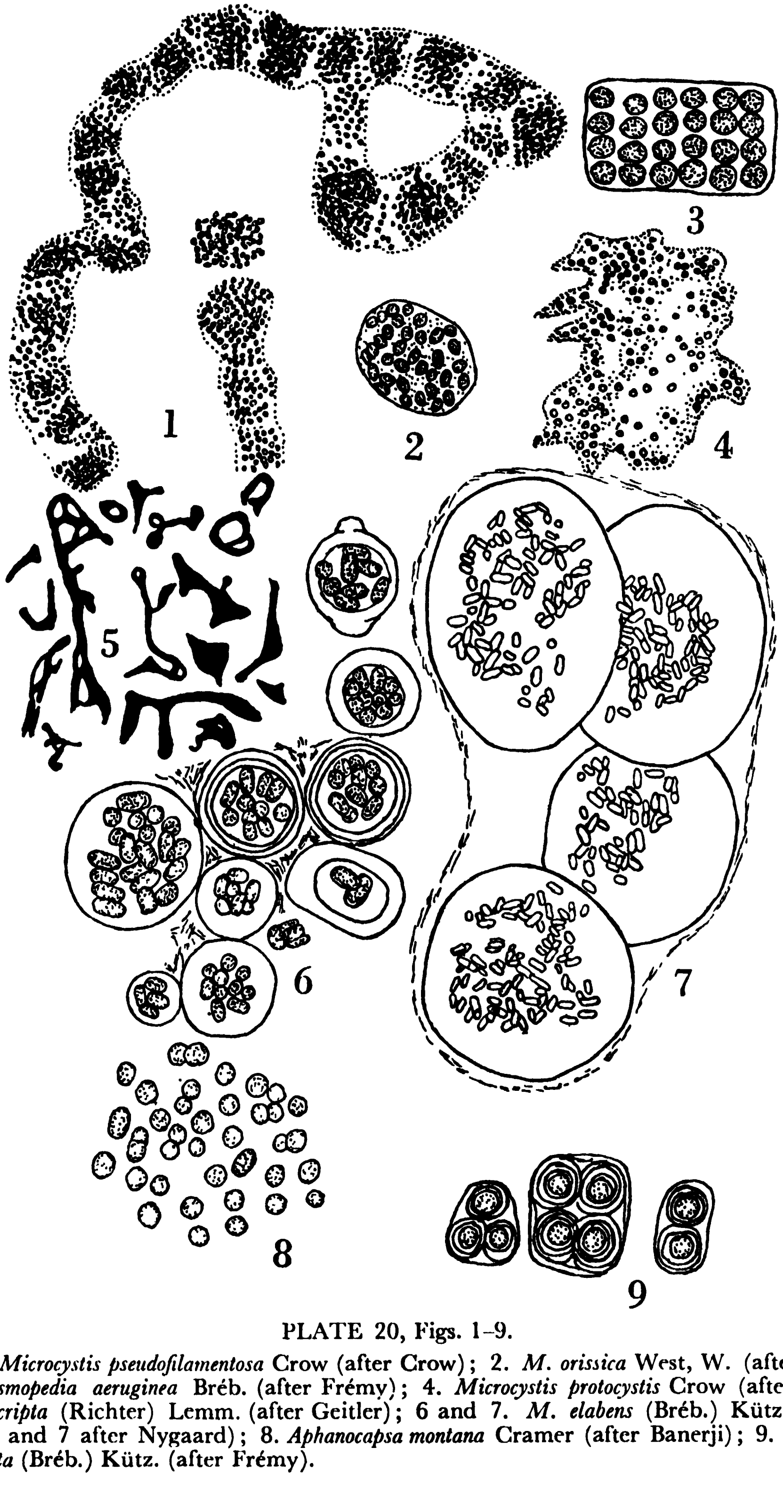

PLATE 20, Figs. 1–9.

1. *Microcystis pseudofilamentosa* Crow (after Crow); 2. *M. orissica* West, W. (after West); 3. *Merismopedia aeruginea* Bréb. (after Frémy); 4. *Microcystis protocystis* Crow (after Crow); 5. *M. scripta* (Richter) Lemm. (after Geitler); 6 and 7. *M. elabens* (Bréb.) Kütz. (6 after Richter and 7 after Nygaard); 8. *Aphanocapsa montana* Cramer (after Banerji); 9. *Gloeocapsa quaternata* (Bréb.) Kütz. (after Frémy).

Pl. 20, Fig. 5

Colonies more or less elongate, like cuneate figures, often clathrate, while young round, ring-like, colonial mucilage distinct; cells 4.5–7 µ, seldom up to 8 µ broad, with gas-vacuoles.

Planktonic in stagnant waters, Calcutta (Banerji, 1936, 295), Madras (Ganapathi, 1940a, 246), Sagar (M.P.) (!).

Rao, C. S., (1940, 125) has recorded from Delhi a planktonic form which is distinguished by the smaller cells (3.3–6.6 µ br.) and the colonies being more perforated.

### 10. **Microcystis aeruginosa** Kütz.

Tab. Phycologicae, 1 : 8, pl. 8, fig. 1, 1846; Crow, Tax. genus *Microcystis*, New Phytol. 22: 61, fig. a, 1923a; Frémy, Myxo. d'Afr. équat. franc., 18, fig. 15, 1929; Geitler, Kryptogamenflora, 137, fig. 59d, 1932; Frémy, Cyano. cotes d'Eur., 10, pl. 1, fig. 6, 1933.

= *Clathrocystis aeruginosa* (Kütz.) Henfrey, J. Roy. micr. Soc.: 53, pl. 4, figs. 28-36, 1856; Forti in De Toni, Sylloge Algarum, 5: 94, 1907.

= *Anacystis cyanea* (Kütz.) Drouet & Daily Rev. Coccoid Myxophyceae, 36, 1956, *pro parte*; Incl: var. *major* (Wittr.) Smith, Prel., list of Algae of Wisc. lakes, Trans. Wisc. Acad. Sci., 18: 2, 1916 and other varieties and forms of *M. aeruginosa*.

Pl. 17, Figs. 1, 2, 6 & Pl. 18, Fig. 10

Colonies when young round or slightly longer than broad, solid, when old becoming clathrate, with distinct hyaline colonial mucilage; cells 3–7 µ in diam., spherical, generally with gas-vacuoles.

Generally in plankton forming water-bloom in stagnant waters such as temple tanks etc.: — Sibpur and Calcutta (Martens, 1870a, 10; Prain, 1905, 332; Biswas, 1927, 51; 1942, 198; Banerji, 1936, 293), salt lakes, Calcutta (Biswas, 1926, 17); Igatpuri and Bombay (Schmidle, 1900b, 162; Dixit, 1936, 94; Gonzalves and Joshi, 1943a, 37), Banaras (Bharadwaja, 1935, 95), Berhampur (Rao, C. B., 1938b, 158), Vanchiyur near Trivandrum (Parukutty, 1940, 117), Delhi (Rao, C. S., 1940, 125), Madras, Sholavaram lake, Mettur lake (Ganapathi, 1940a, 240; 1940b, 74; 1949) many temple tanks in Madras, Tirupati, Salem, (!); Hyderabad (Ghousuddin, 1936, 149), Sagar (M.P.) lake (!) in India; Perediniya (West and West, 1902, 205), Colombo lake, (Lemmermann, 1907, 267); Kalawewa tank, Anuradhapura, Andankulam tank near Trincomalie, Andangewamahawewa tank near Haberane, Balaluwewa tank (Crow, 1923a, 61; 1923b, 139), in Ceylon; Kolodyne valley in Arracan Burma (Martens, 1871b, 461; Theobald, 1883, 21) Rangoon (Ghose, 1925, 245; 1927, 79), in Tanuggyi canal and Myingon (Skuja, 1949, 15) in

Burma; Kuala Lampur in Malaya (Biswas, 1929, 408); and Lahore, Punjab (Ghose, 1919, 9; 1924, 337; Randhawa, 1936c, 40) in Pakistan.

Following Crow (1923a, 61) var. *major* (Pl. 17, Fig. 2) is included here in the species itself.

Rao, C. B. (1937b, 341, fig. 1A, C) describes var. *elongata* Rao—Colonies spherical or elongated, solid or broken through to form a net, broken parts looking like filaments; sheath indistinct, stained violet with methylene blue; cells pale blue-green, more or less spherical, with gas-vacuoles, 2–2.8 μ broad (Pl. 19, Fig. 3). The variety differs from the type in the smaller cells and in the resemblance of broken colonies to filaments. The variation in the species itself is so much that it is not desirable to keep this variety separate. Drouet and Daily (1956, 37) include this species under *Anacystis cyanea* (Kütz.) D. & D.

### 11. **Microcystis flos-aquae** (Wittr.) Kirchner

in Engler and Prantl, Natürlichen Pflanzenfam., I. (1a): 56, fig. 49(N), 1898; Forti in De Toni, Sylloge Algarum, 5: 86, 1907; Crow, Tax. gen. *Microcystis*, New Phytol., 22: 61, 1923a; Frémy, Myxo. d'Afr. equat. franc., 19, fig. 16, 1929; Geitler, Kryptogamenflora, 138, fig. 59, e, f, 1932.

= *Microcystis aeruginosa* f. *flos-aquae* (Wittr.) Elenkin, Monogr. Algar. Cyano., pars spec., 1: 103, 1938.

= *Anacystis cyanea* (Kütz.) Drouet & Daily, Butler Univ. Bot. Stud., 10: 221, 1952; Rev. Coccoid Myxophyceae, 36, 1956 (p.p.).

Pl. 17, Fig. 11 & Pl. 18, Fig. 11

Colonies roughly spherical, ellipsoidal, or somewhat elongate or often squarish in optical section, not clathrate, with indistinct colonial mucilage; cells 3–7 μ in diam., spherical, with gas-vacuoles; nannocytes present.

Planktonic in lakes, tanks, and ponds, often as a water bloom.—Ceylon (Crow, 1923a, 61; 1923b, 283; Skvortzow, 1928, 109), Assam (Brühl and Biswas, 1926, 263), Benares (Bharadwaja, 1935, 95), Bombay (Dixit, 1936, 95; Gonzalves and Joshi, 1946, 175), Calcutta (Banerji, 1936, 293; Biswas, 1942, 198), Andhra (Rao, C. B., 1938a, 81), Madras (Frémy, 1942, 21; Ganapathi, 1940a, 246; 1943, 53), Orissa (Rao, C. B., 1938b, 158), Delhi (Rao, C. S., 1940, 125), Bihar (Rao, C. S., 1939, 143), and Burma (Skuja, 1949, 15), also Madras, Salem, Trivandrum, Bangalore, Pudukkotah (!).

### 12. **Microcystis pseudofilamentosa** Crow

Tax. gen. *Microcystis*, New Phytol., 22: 64, pl. 1, fig. c. f. 1923a; Geitler, Kryptogamenflora, 138, fig. 61, 1932.

= *M. aeruginosa* f. *pseudofilamentosa* (Crow) Elenkin, Monogr. Algar. Cyano., pars spec., 1: 105, 1938.

= *Anacystis cyanea* (Kütz.) Drouet & Daily, Rev. Coccoid Myxophyceae, 12: 37, 1956 (p.p.).

Pl. 18, Fig. 9 & Pl. 20, Fig. 1

Colonies very long and narrowing, consisting of a series of partial colonies and constricted at intervals, sometimes considerably widened at places, broken through or reticulate; margins of colonial mucilage indistinct; colonies varying greatly in size, sometimes twenty times as long as broad, frequently 200–300 μ in length, 20–30 μ in width, partial colonies being about equal in length and width; cells 3–7 μ diam., spherical with gas-vacuoles.

Planktonic in a lake Nuwarawewa at Anuradhapura, Ceylon (Crow, 1923a, 64; 1923b, 139); in stagnant waters, Calcutta (Banerji, 1936, 295), and Madras (!).

### 13. **Microcystis ramosa** Bharadwaja

Myxophyceae of the United Provinces, I, Proc. Indian Acad. Sci., B. 2: 96, fig. 1A, 1935.

= *Anacystis cyanea* (Kütz.) Drouet & Daily, Rev. Coccoid Myxo., 37, 1956 (p.p.).

Pl. 19, Fig. 4

Colonies long, varying greatly in form and size, irregularly branched, constricted at intervals to form daughter colonies which are ultimately broken off, daughter colonies at first almost compact and rounded, later elongated and irregularly branched, like the parent colony up to 80 μ broad and up to 1600 μ long; sheath thick, unstratified, hyaline and rather indistinct, stained violet with methylene blue; cells spherical with gas-vacuoles, 3–5 μ long.

Planktonic in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

This alga resembles *M. pseudofilamentosa* but has a longer colony, smaller cells, and is not reticulate.

Drouet (1939) includes it under *M. aeruginosa.*

### 14. **Microcystis stagnalis** Lemm.

Forschungsber. biol. Stat. Plön, 10: 150, 1903; Arkiv for Bot., 2: 146, 1904, Forti in De Toni, Sylloge Algarum, 5: 87, 1907; Geitler, Kryptogamenflora, 143, 1932.

= *Polycystis stagnalis* Lemm., Beitr. Kenn. der Planktonalg., III, Ber. dtsch. bot. Ges., 18: 24, 1900.

= *M. pulverea* (Wood) Elenk. f. *stagnalis* (Lemm.) Elenkin, Monogr. Algar. Cyano., pars. spec., 1: 117, 1938.

= *Anacystis montana* (Kütz.) Drouet & Daily, Butler Univ. Bot. Stud., 10: 221, 1952; Rev. Coccoid Myxophyceae, 66, 1956 (p.p.).

Colonies very long and small, sometimes expanding and clathrate, colonial mucilage indistinct; cells very closely arranged, spherical, 1–2 µ diam., pale blue-green, without gas-vacuoles.

In a tank at Bandra, Bombay (Gonzalves and Joshi, 1946, 175).

### 15. **Microcystis holsatica** Lemmermann

Kryptogamenflora der Mark Brandenburg, 3: 77, 1910; Geitler, Kryptogamenflora, 143, 1932.

= *Clathrocystis holsatica* Lemm., Forschungsber. biol. Stat. Plön, 10: 150, 1903; Forti in De Toni, Sylloge Algarum, 5: 95, 1907.

= *M. pulverea* f. *holsatica* (Lemm.) Elenkin, Monogr. Alg. Cyano., pars. spec., 1: 124, 1938.

= *Anacystis incerta* (Lemm.) Drouet & Daily, Rev. Coccoid Myxophyceae, 42, 1956 (p.p.).

Colonies spherical, clathrate, margins of colonial mucilage well defined; cells closely arranged, 1 µ diam., spherical or subspherical, with gas-vacuoles, blue-green.

Planktonic.—Tank Andankulam, near Trincomalee, Ceylon (Crow, 1923a, 65; 1923b, 139).

### 16. **Microcystis pulverea** (Wood) Forti

in De Toni, Sylloge Algarum, 5: 92, 1907; Crow, Tax. gen. *Microcystis,* New Phytol., 22: 66, 1923a; Geitler, Kryptogamenflora, 143, 1932.

= *M. pulverea* (Wood) Elenkin, Monogr. Algar. Cyano., pars. spec., 1: 117, 1938 (p.p.).

= *Anacystis montana* (Kütz.) Drouet & Daily, f. *minor* Drouet & Daily, Butler Univ. Bot. Studies, 10: 221, 1952; Rev. Coccoid Myxophyceae, 66, 1956 (p.p.).

Colonies rounded to ellipsoidal, often many together, limits of colonial mucilage distinct; cells spherical or ellipsoidal, closely arranged 2–3 µ broad, blue-green or olive-green, without gas-vacuoles.

Planktonic, in a lake at Colombo and a tank at Dambella in Ceylon (Crow, 1923a, 66; 1923b, 140); on moist soil rich in lime, Perukada, Travancore (Parukutty, 1940, 117); planktonic, Mandalay and epiphytic, Rangoon (Skuja, 1949, 15).

### Var. **incerta** (Lemm.) Crow

Tax. gen. *Microcystis,* New Phytol., 22: 66, 1923a; = *Microcystis incerta* Lemm., Abh. Nat. Ver. Bremen, 17: 342, 1902; Frémy, Myxo. d'Afr. équat. franc., 20, 1929. incl. f. *elongata* Crow, New Phytol., 66, 1923a.

Colonies generally elongated up to 4 times, cells 1–2 μ diam.

Planktonic in Colombo lake, tank at Dambella and rock pools connected to tank Kalawewa in Ceylon (Crow, 1923a, 66; 1923b, 140); planktonic, Myingon, Rangoon, and epiphytic in Mandalay (Skuja, 1949, 15); and on moist soil rich in lime, Perukada, Trivandrum (Parukutty, 1940, 117).

### 17. **Microcystis orissica** West, W.

Descriptions of new spp. of Algae etc., Journ. Asiatic Soc., Bengal, 7: 84, fig. 9, 1911; Geitler, Kryptogamenflora, 144, fig. 62d, 1932.

= *Coccochloris peniocystis* (Kütz.) Drouet & Daily, Lloydia, 11: 78, 1948; Rev. Coccoid Myxophyceae, 32, 1956 (p.p.).

Pl. 20, Fig. 2

Colony rounded or ellipsoidal, dull olive-green, mostly 24–40 μ br., colonial mucilage distinct; cells short ellipsoidal, 0.8–0.9 μ seldom up to 1.0 μ broad, blue-green.

In the colonial mucilage of a Bryozoan, *Pectinatella burmanica,* Sur lake, Puri (West, *loc. cit.*).

### 18. **Microcystis elabens** (Bréb.) Kütz.

in Kützing, Tab. Phycologicae, 1 : 6, pl. 8, 1846; Forti in De Toni, Sylloge Algarum, 5: 88, 1907; Frémy, Myxo. d'Afr. équat franc., 20, fig. 19, 1929; Geitler, Kryptogamenflora, 145, fig. 65, 1932; Frémy, Cyano. cotes d'Eur., 11, pl. 2, fig. 1, 1933.

incl. var. *major* Bachmann, Beitr. Algenfl. Westgrönland, Mitt. Naturf. Ges. Luzern, 8: 11, fig. 1, g.h. 1849.

= *Microhaloa elabens* Bréb. in Meneghini, Nostoch., 104.

= *Polycystis elabens* Kützing, Species Algarum, 210, 1849.

= *Coccochloris elabens* (Bréb.) Drouet & Daily, Rev. Coccoid Myxophyceae, 46, 1956 (p.p.).

Pl. 18, Fig. 12 & Pl. 20, Figs. 6, 7

Colony spherical, or flat and expanding, blue-green or olive-green, when old together with a number of daughter colonies; cells oblong, 2–4.5 μ broad, (3–) 4–8.5 μ long, with gas-vacuoles.

Loktak Lake, Assam (Bruhl & Biswas, 1926, 283); slow sand filters, Madras (Ganapati, 1940a, 246) and Beach pools, Madras (!).

Nygaard describes a variety, *minor* Nygaard (Plankton, two lakes, Malayan region, Vidensk. Medd. Dansk nat. For., 82, 1926) with cells 1–1.5 μ broad and 3–5 μ long.

Elenkin (Monogr. Algar. Cyano., pars. spec., 1: 146, 1938), includes this species under *Aphanothece,* as *A. elabens* (Bréb.) Elenk., which seems to be somewhat justified.

## SPECIES INQUIRENDA

### **Microcystis insignis** (Beck) comb. nov.

= *Clathrocystis insignis* Beck in Beck, Mus. Vindob. Krypt. Exs., 2: 227, 1896; Beck and Zahlbruchner, Ann. de. K. K. Naturhist. Hofmuseums, 83, 1897; Forti in De Toni, Sylloge Algarum, 5: 96, 1907.

= *Polycystis* (*Clathrocystis*) *insignis* Beck (?), Drouet & Daily, Rev. Coccoid Myxophyceae, 36, 1956.

Colonies distinct, macroscopic, 3 mm. diam., globose, more or less diffluent; cells spherical or subspherical, 3.7–4.9 μ long, 3.7 μ broad, pale blue-green.

On surface of aquatic plants in a tank, Bombay (Beck, *loc. cit.*).

Drouet & Daily (1956, p. 36) place this species in *Anacystis cyanea* (Kütz.) Drouet & Daily.

## **CHROOCOCCUS** Näg.

Gatt. einzell. Algen, 45, 1849.

Cells spherical or subspherical, hemispherical, after division in small groups of 2–4 individuals, sometimes 8-16, rarely single, in a gelatinous or mucous matrix; sheath of individual cells distinct, firm, generally lamellated, in some homogeneous, persistently or irregularly broken; reproduction by cell division and fragmentation of colonies; division of cells in three directions. Nannocytes occasionally seen.

Type species: *C. turgidus* (Kütz.) Näg. is designated as the type by Geitler (1942). Nägeli himself has designated *Chroococcus rufescens* (Bréb.) Näg. as the type. De Toni (1907, p. 25) excludes this as a *Pleurococcus* (*see* also Geitler, 1942, p. 54).

Lund, J. W. G. (1954) has described the movement of cells in *Chroococcus turgidus.*

There is a regular rhythm in the division and growth of the individual. Vogl (1927) has studied the cell division *in vivo.*

Nannocyte formation has been described by Crow (Arch. Protistenk., 61 : 1928).

Drouet & Daily (1956) in their revision include most of the species under *Anacystis.* They include *Chr. cohaerens, Chr. pallidus* in *Anacystis thermalis* (Menegh.) Dr. and D. f. *thermalis* Dr. and D., *Chr. limneticus* and *Chr. gomontii* in *A. thermalis* f. *major* (Lagerh.) Dr. and D., *Chr. giganteus* West, *Chr. indicus* var. *epiphyticus* Ghose, *Chr. multicoloratus, Chr. tenax, Chr. turgidus* incl. var. *fuscescens* (Kütz.) Forti and var. *maximus* Nygaard and *Chr. westii* in *Anacystis dimidiata* (Kütz.) Dr. and D., *Chr. indicus* in *Anacystis cyanea* (Kütz.) Dr. and D., *Chr. schizodermaticus* and *Chr. varius* in *Anacystis montana* f. *montana* Dr. and D., *Chr. minimus* in *Gomphosphaeria lacustris* Chodat, *Chr. minimus* var. *crassus* Rao, *Chr. minutus, Chr. montanus* and *Chr. montanus* var. *hyalinus* Rao in *Coccochloris stagnina* Sprengel and *Chr. hansgirgii* in *Entophysalis rivularis* (Kütz.) Dr. and D., f. *rivularis* Dr. and D. They exclude three species, *Chr. granulosus* Zell., (= *Palmogloea protuberans* (Sm. and S.) Kütz., *Chr. macrococcus* (Kütz.) Rabenh. ( = encysted *Peridinium*), and *Chr. minor* (Kütz.) Näg. (= *Stichococcus subtilis* (Kütz.) Klerck.).

Daily (1942) points out the close similarity between *Gloeocapsa* and *Chroococcus* and seeks to differentiate the two on the basis of the presence or absence of colored sheaths.

Hollerbach in Elenkin (1938) includes *Chroococcus* in *Gloeocapsa* itself.

## KEY TO THE SPECIES

1. Cells single or after division mostly 8 (–16) together .......... 2
1. Cells forming a large thallus .......... 9
    2. Sheath lamellated .......... 3
    2. Sheath not lamellated .......... 8
3. Envelope colorless .......... 4
3. Envelope yellowish or brownish .......... 7
    4. Cells with sheath 54–58 μ broad .......... 1. *Chr. giganteus* (p. 101)
    4. Cells with sheath less than 32 μ broad .......... 5
    4. Cells with sheath 30–80 μ diam. .......... 2. *Chr. macrococcus* (p. 101)
5. Lamellae of the sheath distinct .......... 3. *Chr. turgidus* (p. 101)
5. Lamellae of the sheath indistinct .......... 6
    6. Cells violet in color .......... 4. *Chr. westii* (p. 103)
    6. Cells otherwise .......... 5. *Chr. tenax* (p. 103)
7. Cells without sheath 5.8–11 μ broad .......... 6. *Chr. schizodermaticus* (p. 103)
7. Cells without sheath 16–21 μ broad .......... 5. *Chr. tenax* (p. 103)
    8. Cells without sheath 4–10 μ broad .......... 7. *Chr. minutus* (p. 103)
    8. Cells without sheath 3–4 μ broad .......... 8. *Chr. minor* (p. 105)
    8. Cells without sheath 8–12 μ broad .......... 9. *Chr. hansgirgi* (p. 105)
    8. Cells without sheath 7–9 μ broad .......... 10. *Chr. gomontii* (p. 105)

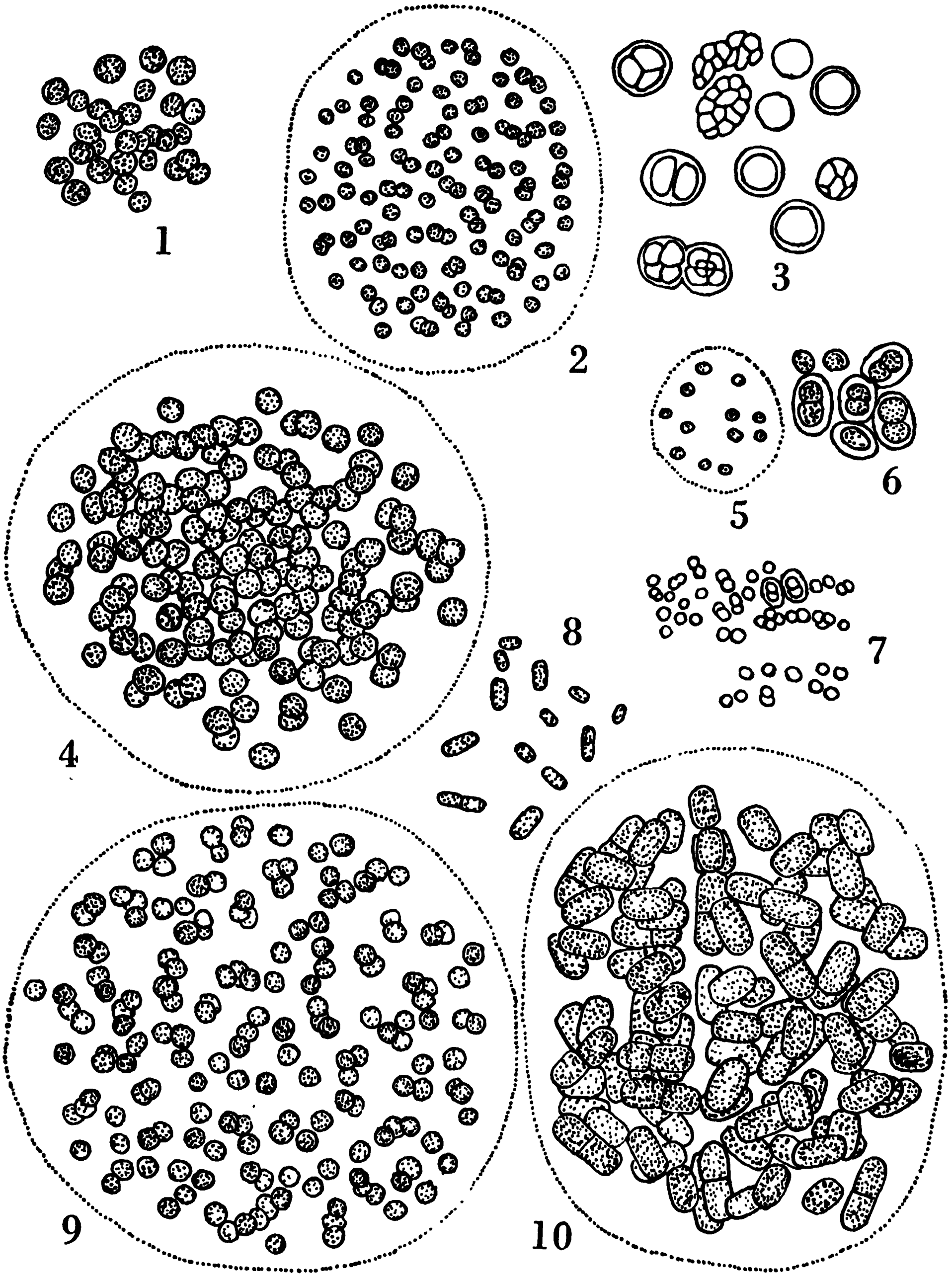

PLATE 21, Figs. 1–10.

1. *Aphanocapsa littoralis* Hansg. (after Iyengar and Desikachary); 2. *A. pulchra* (Kütz.) Rabenh. (after Smith); 3. *A. biformis* A. Br. (after Geitler); 4. *A. biformis* A. Br. (after Smith as *A. rivularis*); 5. *A. elachista* West et West (after West and West); 6. *A. virescens* (Hass.) Rabenh. (after Hansgirg from Tilden); 7. *A. muscicola* (Menegh.) Wille (after Wille); 8. *Aphanothece castagnei* (Bréb.) Rabenh. (after Wille); 9. *Aphanocapsa grevillei* (Hass.) Rabenh. (after Smith); 10. *Aphanothece prasina* (after Smith) = *A. stagnina* (Spreng.) A. Br.

| | | |
|---|---|---|
| 9. | Colonies free-swimming | 10 |
| 9. | Colonies attached, mostly subaerial | 11 |
| 10. | Cells 2.3 μ broad | 11. *Chr. minimus* (p. 106) |
| 10. | Cells 3–4 μ broad | 12. *Chr. dispersus* (p. 106) |
| 10. | Cells bigger | 13. *Chr. limneticus* (p. 107) |
| 11. | Sheath lamellated | 12 |
| 11. | Sheath unlamellated | 13 |
| 12. | Sheath thick, colorless or yellowish, cells 2–4 μ diam. | 14. *Chr. varius* (p. 107) |
| 12. | Sheath thin, intensely yellow, (3–) 5–6 (–9) μ broad, colonies 4.5–7 (–15) μ diam. | 15. *Chr. montanus* (p. 108) |
| 13. | Cells without sheath 4–8 μ broad | 16. *Chr. pallidus* (p. 108) |
| 13. | Cells without sheath 3.5–7.5 μ broad | 17. *Chr. indicus* (p. 109) |
| 13. | Cells smaller | 14 |
| 14. | Cells less than 2 μ broad | 18. *Chr. multicoloratus* (p. 109) |
| 14. | Cells more than 2 μ broad | 15 |
| 15. | Cells attached together forming flakes | 19. *Chr. cohaerens* (p. 111) |
| 15. | Cells not attached together | 8. *Chr. minor* (p. 105) |

### 1. **Chroococcus giganteus** West, W.

Alg. Engl. Lake Dist., Trans. Roy. micr. Soc., 1892: 741, pl. 10, figs. 59–60, 1892; Forti in De Toni, Sylloge Algarum, 5: 11, 1907; Geitler, Kryptogamenflora, 227, fig. 109a, 1932.

Pl. 26, Fig. 1

Cells mostly two, seldom three or four together in groups, bright blue-green, without sheath 5.4–5.5 μ broad, with sheath 67–70 μ broad; sheath 5. 4–6 μ thick, lamellated (2–3 layers), colorless.

Free floating (planktonic) in ponds and tanks.—Hyderabad (Ghousuddin, 1936, 149) in India and Maymyo islands in Burma (Ghose, 1927d, 253).

### 2. **Chroococcus macrococcus** (Kütz.) Rabenh.

Krypto. fl. Sachsen, 1: 70, 1863; Fl. Eur. Alg., 2: 33, 1865; Forti in De Toni, Sylloge Algarum, 5: 8, 1907; Frémy, Myxo. d'Afr. équat. franc., 43, fig. 45, 1929.

Pl. 27, Figs. 3, 9, 10

Thallus mucilaginous, somewhat broad, yellowish brown, more or less dilated; cells spherical, 2–4 together, also single, 25–50 μ diam., with sheath 30–80 μ diam.; sheath thick, colorless, lamellated.

In cultures of soils, Lahore in Pakistan (Singh, H. D., 1933, 106).

### 3. **Chroococcus turgidus** (Kütz.) Näg.

Gatt. einzell. Algen, 46, 1849; Forti in De Toni, Sylloge Algarum, 5: 12, 1907; Frémy, Myxo. d'Afr. équat. franc., 36, fig. 40, 1929; Geitler, Kryptogamenflora, 228, fig. 109b, 110, 1932; Frémy, Cyano. cotes d'Eur., 24, pl. 4, fig. 5, 1933.

Pl. 26, Fig. 6

Cells spherical or ellipsoidal single, or in groups of mostly 2–4, very seldom many, blue-green, olive green or yellowish, without sheath 8–32 μ, with sheath 13–25 μ diam. rarely 40 μ; sheath colorless, not distinctly lamellated.

Planktonic, in mangrooves, attached to submerged parts, subaerial on tree trunks.—Lahore in Pakistan (Ghose, 1919, 9; 1924, 336); Hanaratgodha in Ceylon (West and West, 1902, 205); Rangoon in Burma (Skuja, 1949, 20); Bombay (Schmidle, 1900b, 162; Gonzalves and Joshi, 1946, 175), Faridpur and Berhampur (Bruhl and Biswas, 1922a, 2), Calcutta (Bruhl and Biswas, 1923, 17; Biswas, 1925, 4; Banerji, 1936, 278), Hyderabad (Ghousuddin, 1936, 149), Benaras (Rao, C. B., 1937b, 344), Namdur in Andhra (Rao, C. B., 1938a, 82).

Var. **maximus** Nygaard

Vidensk. Medd. Dansk Naturh. Fören. Kjobenh., 82: 201, figs. 1–6, 1926; Geitler, Kryptogamenflora, 229, fig. 109c, 1932.

Pl. 24, Fig. 2 & Pl. 26, Fig. 8

Cells in groups of 2–4 or 8, 22–45 μ diam., blue-green; sheath colorless 5–10 μ diam., much lamellated in the inner portions; two-celled colonies 44–51 × 56–65 μ and 4–8 celled colonies 58–79 × 73–110 μ.

In running soiled trench water, Rangoon, in Burma (Skuja, 1949, 20).

Skuja (1949, pl. 1, fig. 10) records a large form with cells without sheath 40–44 μ diam. and with sheath up to 55 μ diam. The two-celled colonies were up to 55 × 80 μ (Pl. 24, Fig. 2).

Var. **solitarius** Ghose

Myxophyceae from Mergui, J. Burma Res. Soc., 17: 245, pl. 2, fig. 2, 1927.

Pl. 26, Fig. 14

Cells single globose or elliptical, bright blue-green, with sheath 11–13 μ and without sheath 9–11 μ diam., sheath thick, colorless, lamellated.

Sticking to old empty sheaths of other blue-green algae, on barks Kamaw, Burma. (Ghose, *loc. cit.*).

Var. **fuscescens** (Kütz.) Forti

in De Toni, Sylloge Algarum, 5: 13, 1907.

Protoplasm brownish.

North India (Carter, 1926, 267).

Geitler (1932, 230) considers this the same as the type of the species but with only a brownish protoplast.

### 4. **Chroococcus westii** (W. West) Boye-Petersen

Freshwater Algae of Iceland, 2: 263, fig. 1, 1923; Geitler, Kryptogamenflora, 230, fig. 108d, 1932.

Cells single or in groups of 2–4, without sheath 13–27 μ diam., with sheath 18–32 μ diam., violet; sheath colorless, distinctly lamellated, colored yellow to brownish with chlor-zinc-iodide.

Type variety not recorded so far.

A new variety, *terrestris*, (*nomen nudum*) has been reported by Mitra (1951, 36) from the paddyfields, of Allahabad.

### 5. **Chroococcus tenax** (Kirchn.) Hieron.

Beitr. Biol. Pfl., 5: 483, pl. 17, fig. 11, 1892; Geitler, Kryptogamenflora, 231, fig. 111a, 1932.

Pl. 26, Figs. 7, 16

Cells mostly in groups of 2–4, sometimes 8–16, blue-green or olive colored, without sheath 16–21 μ, with sheath 20–26 μ in diam.; sheath colorless or yellow to brown, very thick, very distinctly lamellated, 3–4 lamellae.

In slow sand filters, Madras (Ganapathi, 1940a, 246).

### 6. **Chroococcus schizodermaticus** West

Alg. Engl. Lake Dist., Trans. Roy. micr. Soc., 1892: 742, pl. 10, figs. 61–63, 1892; Forti in De Toni, Sylloge Algarum, 5: 13, 1907; Frémy, Myxo. d'Afr. équat. franc., 38, fig. 41, 1929; Geitler, Kryptogamenflora, 232, fig. 111b, 1932.

Pl. 26, Fig. 17

Cells in groups of 2–4, blue-green, without sheath 5.8–11 μ, with sheath 21–42 μ diam.; sheath yellow to brown, very distinct, lamellated, 5–10 lamellae, outer layers often broken.

Paddyfields, Dahisar, Bombay (Gonzalves and Gangla, 1949, 54).

### 7. **Chroococcus minutus** (Kütz.) Näg.

Gatt. einzell. Algen, 46, 1849; Forti in De Toni, Sylloge Algarum, 5: 14, 1907; Frémy, Myxo. d'Afr. équat. franc., 39, fig. 42, 1929; Geitler, Kryptogamenflora, 232, fig. 112a, 113c, 1932; Frémy, Cyano. cotes d'Eur., 24, pl. 4, fig. 6, 1933.

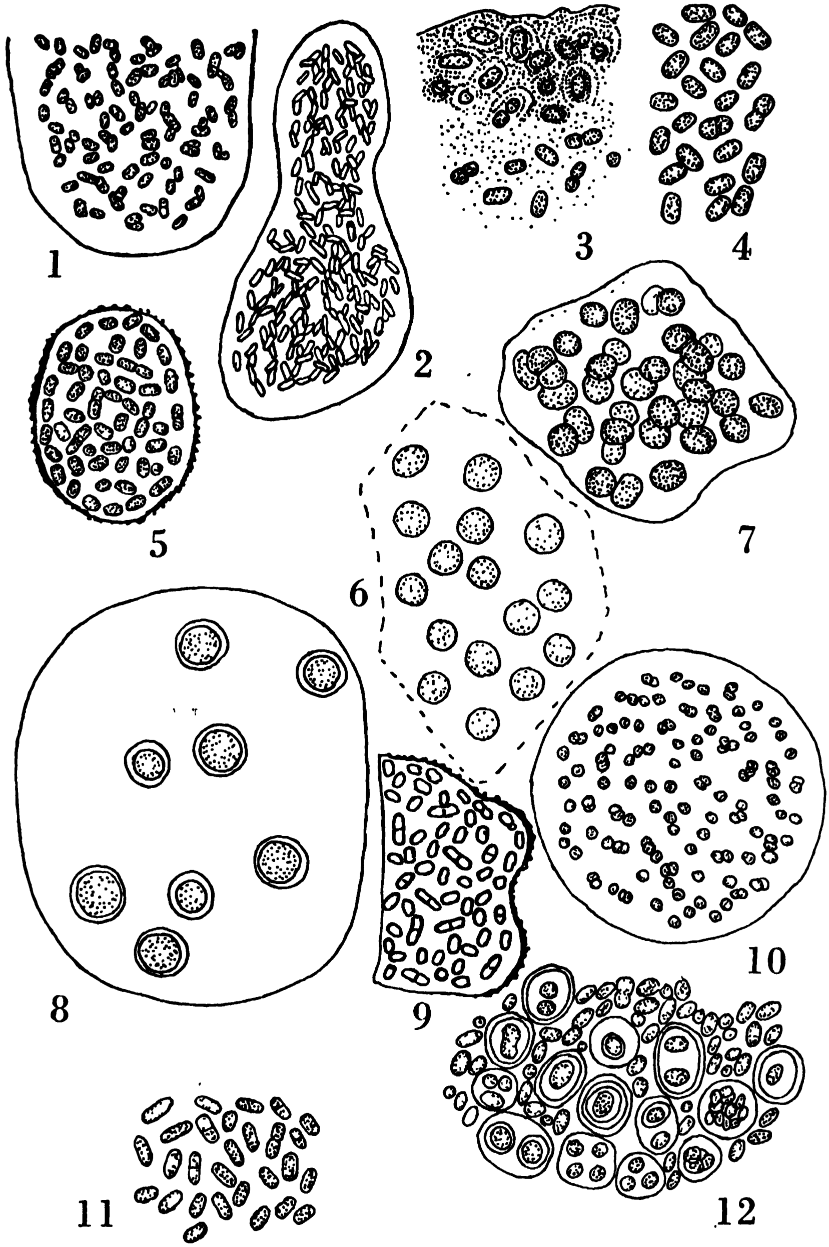

PLATE 22, Figs. 1–12.

1. *Aphanothece nidulans* Richter (after Smith); 2. *A. clathrata* West et West (after Smith); 3. *A. pallida* (Kutz.) Rabenh. (after Geitler); 4, 5, 9. *A. microscopica* Näg. (4 after Frémy, 5 and 9 after Nägeli); 6. *Aphanocapsa crassa* Ghose (after Ghose); 7. *Aphanothece naegelii* Wartm. (after Skuja); 8. *Aphanocapsa banaresensis* Bharadw. (after Bharadwaja); 10. *A. elachista* var. *conferta* West et West (after Smith); 11. *Aphanothece saxicola* Näg. (after Frémy); 12. *A. bullosa* (Menegh.) Rabenh. (after Meneghini).

Pl. 24, Fig. 4 & Pl. 26, Figs. 4, 15

Cells spherical or oblong, single or in groups of 2–4, light blue-green, with sheath 6–15 μ diam., and without sheath 4–10 μ diam., colonies 10–13 × 15–20 μ; sheath not lamellated, colorless.

Planktonic (or tycholimnetic) among other algae. — Hambantota in Ceylon (Crow, 1923b, 114); Rangoon and Mandalay in Burma (Skuja, 1949, 19); in soils, Lahore in Pakistan (Singh, H. D., 1933, 106); Benaras (Rao, C. B., 1937b, 344), soils from Benaras, Muzafarpur, Gorakhpur, and Basti (Singh, R. N., 1939a, 58), Shembaganur (Frémy, 1942, 21), soils from rice fields, Allahabad (Mitra, 1951, 359); on the barks of trees, Calcutta (Bruhl and Biswas, 1923, 1), epiphytic on aquatic plants, Mandalay, Rangoon (Skuja, 1949, 19) and in the mucilage of other Myxophyceae, Calcutta (Banerji, 1936, 299).

Skuja reports a form from Burma with a thick, occasionally lamellated sheath, the colony having 4–16 cells and 25–50 μ × 23–26 μ. The cells are 6–10 μ in diam. with sheath.

### 8. **Chroococcus minor** (Kütz.) Näg.

Gatt. einzell. Algen, 47, pl. 1, A, fig. 4, 1849; Forti in De Toni, Sylloge Algarum, 5: 23, 1907; Frémy, Myxo. d'Afr. équat. franc., 45, fig. 50, 1929; Geitler, Kryptogamenflora, 240, fig. 116g, 1932.

Pl. 24, Fig. 1

Thallus slimy-gelatinous, dirty blue-green, or olive green; cells spherical, 3–4 μ in diam., singly or in pairs, seldom 4 or 8; sheath colorless, very thin, hardly visible.

On *Sonneratia apetala*, Elephant Point, (Zellèr, 1873b, 175; Theobald, 1883, 24), in a stagnant pond, Kyauktaga, Pegu Dist., (West and West, 1907, 242) and Rangoon (Skuja, 1949, 19) in Burma; in N. India (Turner, 1882, 12).

### 9. **Chroococcus hansgirgi** Schmidle

Allg. bot. Zeitschr., 6(2): 78, 1900a; Hedwigia, 39: 187, 1900b; Forti in De Toni, Sylloge Algarum, 5: 7, 1907.

Cells reddish, violet-blue, single, spherical or oblong, 8–12 μ broad, 16 μ long diam.; sheath thin, hyaline, adhering; cell-contents homogeneous, violet.

On molluscan shells in a lake, Poona (Schmidle *loc. cit.*)

### 10. **Chroococcus gomontii** Nygaard

Plankton lakes Malay Region, Vidensk. Medd. Dansk nat. Foren., 82: 202, pl. 1, fig. 15, 1926; Geitler, Kryptogamenflora, 240, 1932.

Cells 16–32 in groups of four in a common mucilaginous envelope, 7–9 μ diam., colony 46–48 × 58–59 μ; sheath rounded, colorless, unlamellated.

Malaya (Nygaard).

### 11. **Chroococcus minimus** (Keissler) Lemm.

Ark. f. Bot., 2(2): 102, 1904; Frémy, Myxo. d'Afr. équat. franc., 42, 1929; Geitler, Kryptogamenflora, 232, 1932.

= *Chr. minutus* var. *minimus* Keissler, Zur Kenntnis des Plankton des Attersees, Zool. bot. Ges. Wien, 5: 394, 1901; Forti in De Toni, Sylloge Algarum, 5: 15, 1907.

Thallus mucilaginous; cells spherical or ellipsoid, generally in twos or many in spherical colonies, without sheath 2–3 μ diam., with sheath 4–5 μ in diam; colonies 35–75 μ diam; sheath unlamellated.

Planktonic in tanks and lakes. — Anuradhapura and Nuwarawewa in Ceylon (Crow, 1923b, 114); Benaras in India (Rao, C. B., 1937b, 345).

Rao gives detailed measurements of the algae (Cells 1.6–2.5 (–3) μ broad, 2–3.3 μ long; cells with sheath 3–4.5 μ broad and 3.2–5 μ long; colonies with sheath 4.8–6.4 μ broad and 4.8–8.4 μ (–9.6) μ long).

### Var. **crassus** Rao, C. B.

Myxophyceae of the United Provinces, II, Proc. Indian Acad. Sci., B, 3; 166, fig. 1A, 1936.

Pl. 26, Fig. 13

Thallus membranous, soft, pale blue-green; cells spherical, subspherical or ellipsoidal, single or in more or less rounded or ellipsoid colonies with 2–8 (rarely up to 12) cells, colonies with sheath 4.5–10 μ, × 4–10 μ, rarely up to 14.2 μ; cells 2–4.5 × 2–6.5 μ, with sheath 4.5–8 × 4.5–9.5 μ; sheath distinct, hyaline and lamellated.

On moist bricks, Benaras (Rao, C. B. *loc. cit.*).

The variety differs in having larger cells and is a terrestrial form.

### 12. **Chroococcus dispersus** (v. Keissler) Lemm.

Ark. f. Bot., 2: 102, 1904; Forti in De Toni, Sylloge Algarum, 5: 1907; Geitler, Kryptogamenflora, 233, fig. 113d, 1932.

Cells 4–8, 16 or more in a tabular mucilaginous free-swimming colony, with round margins, either solitary and then widely separated from each other or in groups isolated from each other, light or brilliant blue-green, without sheath 3–4 μ broad, with sheath 5–6 μ diam., colonies or groups 15–20 μ distant; individual envelopes often totally gelatinised, not lamellated, colorless.

Type variety not recorded.

### Var. **minor** Smith, G. M.

Phytoplankton of Inland Lakes of Wisconsin, 1: 28, pl. 1, fig. 3, 1920; Geitler, Kryptogamenflora, 233, 1932.

Cells without sheath 1.75–2.5 μ diam., light gray.

In Plankton, Beira Lake, Nuwarawewa tank, and Gregory Lake, in Ceylon (Holsinger, 1954, 9).

### 13. **Chroococcus limneticus** Lemm.

Beitr. Kenntnis Planktonalg. II, Bot. Cbl., 76: 153, 1898; Forschungsber. f. biol. stat. in Plön, VII, 132, pl. 1, fig. 22, 23, 1899; Forti in De Toni, Sylloge Algarum, 5: 16, 1907; Frémy, Myxo. d'Afr. équat. franc., 40, fig. 44, 1929; Geitler, Kryptogamenflora, 234, fig. 113a, 1932; Frémy, Cyano. cotes d'Eur., 23, pl. 4, fig. 3, 1933.

Pl. 26, Fig. 2

Cells spherical or subspherical after division, 4–32, free floating, mostly in a tabular gelatinous layer, without sheath cells 6–12 μ diam., with sheath 8–14 μ diam.; sheath distinct or diffluent, unlamellated, colorless, colonial mucilage broad, cell divisiòn generally in two, seldom in three directions, cell contents gray, blue-green, olive-green, or yellowish.

In cultures of soils, Lahore (Singh, H. D., 1933, 106).

### Var. **subsalsus** Lemm.

Forschungsber. f. biol. stat. in Plön, 8: 84, 1901; Arkiv f. Bot., 2: 101, pl. 1, fig. 9, 1904; Kryptogamenflora der Mark Brandenburg, 3: 57, 1910; Forti in De Toni, Sylloge Algarum, 5: 16, 1907; Geitler, Kryptogamenflora, 235, 1932.

Cells round or elongate, 16–32 together in free swimming colonies, colonies tabular, blue-green; cells with sheath 4.5–5 μ diam., without sheath 3.5–4.5 μ diam., more or less closely arranged; colonial mucilage round or nearly quadrangular, broad.

In Plankton in Beira lake, Nuwarawewa tank, and Gregory Lake in Ceylon, (Holsinger, 1954, 9).

### 14. **Chroococcus varius** A. Br.

in Rabenhorst, Alg. Eur., 246, 248, 2452, 2459, 1863–78; Forti in De Toni, Sylloge Algarum, 5: 21, 1907; Geitler, Kryptogamenflora, 236, fig. 114a, 1932; Frémy, Cyano. cotes d'Eur., 25, pl. 4, fig. 7, 1933.

Pl. 24, Fig. 5

Thallus gelatinous, dirty olive green or brownish; cells globular, single or 2–4 together, seldom more in small or big groups, irregularly arranged, without sheath 2–4 μ, with sheath 4–8 μ diam., pale blue or olive-green, seldom yellowish or golden yellow; sheath apparently thick, indistinctly lamellated, colorless or yellowish or pale orange yellow.

Epiphytic, Mandalay and on earthenware, Rangoon (Ghose, 1927b, 238; Skuja, 1949, 20); on cemented platform, Benaras (Rao, C. B., 1937b, 345).

### 15. **Chroococcus montanus** Hansgirg

Notarisia, 3: 400, 1888; Prodromus der Algenflora von Böhmens, 2: 160, 1892; Forti in De Toni, Sylloge Algarum, 5: 10, 1907; Frémy, Myxo. d'Afr. équat. franc. 43, 1929; Geitler, Kryptogamenflora, 236, 1932.

Pl. 26, Fig. 12

Thallus slimy, gelatinous, brownish or blackish brown; cells 5–6 μ seldom 3–9 μ diam., single or 2–4, seldom more in irregular groups of 19–25 μ diam., rarely up to 30 μ diam., colonial sheath lamellose.

Type form not recorded.

Rao, C. B. (1937b, 359) describes a form on moist soil, Benaras and the same has been reported also by Rao, C. S. (1940, 126).—Cells 3.3–6.6 × 4–8 μ, with sheath 6–10 (–12.8) × 6–12 μ; colonies with sheath 8.8–16 × 11.2–14.4 μ; sheath hyaline.

### Var. **hyalinus** Rao, C. B.

The Myxophyceae of the United Provinces III, Proc. Indian Acad. Sci., B, 6: 345, fig. 1G, 1937.

Pl. 26, Fig. 11

Stratum thick, mucilaginous, blue-green; cells spherical or subspherical, or elongated, single or 2–4 or occasionally up to 8 in spherical or ellipsoidal colonies; colonies separated; cell 4.8–7.5 × 8–16.5 μ; with sheath 19.8–26 μ × 19–36 μ; sheath thick, hyaline, and lamellated.

On moist soil, Benaras (Rao, C. B. *loc. cit*).

The variety differs in the color of the stratum, the bigger colonies, and in the hyaline thick sheath.

### 16. **Chroococcus pallidus** Näg.

Gatt. einzell. Algen, 46, pl. 1, fig. 2, 1849; Forti in De Toni, Sylloge Algarum, 5: 19, 1907; Frémy, Myxo. d'Afr. équat. franc., 45, fig. 48, 1929; Geitler, Kryptogamenflora, 238, fig. 116b, 1932.

= *Protococcus pallidus* Näg., in Kützing, Species Algarum, 201, 1849.

Pl. 26, Fig. 5

Thallus gelatinous, yellowish or colorless; cells single or 2–4, seldom up to 8 in elliptic oblong colonies, without sheath 5–8 μ, with sheath 7–11.5 (13) μ broad, blue-green or yellow; sheath colorless, unlamellated.

Igatpuri, near Bombay (Kunze *see* De Toni, 1907, 19); on wet soil, Benaras (Rao, C. B., 1937b, 346).

Rao, C. B. (1938a, 82) describes a form growing on brick walls in Namdur in Andhra State which has smaller cells arranged in colonies of 16–20 cells.—Stratum thick, slimy, membranous; cells almost spherical or ellipsoidal, cells 3.2–4.8(–6) × 4–8 μ and with sheath 4.8–6.6 × 9–10 μ; colonies with 2–8 or sometimes up to 16–24 cells when they overlap; colonies with sheath 8–20 × 10–26 μ; sheath thick, hyaline, and unstratified.

Dixit (1936, 95) describes a form growing on stone walls in Mahableshwar, Borivli and Jogeshwari caves, Bombay.—Cells 5.6 × 7.5 μ, with sheath about 11.2 × 14 μ; sheath thick, yellow-brown.

### 17. **Chroococcus indicus** Zeller

Hedwigia, 12: 168, 1873; J. Asiatic Soc. Bengal 42 (2): 176, 1873; Forti in De Toni, Sylloge Algarum, 5: 17, 1907; *non* Bernard, 1908.

Thallus gelatinous, thin, a pale brownish; cells single, oblong to subspherical, 3.5–7.5 μ diam., greenish; sheath hyaline, conspicuous, contents granular.

In forest swamps, Prome, Burma (Zeller, *loc. cit.*; Theobald, 1883, 24), and on the barks of *Moringa pterygosperma* (Ghose, 1927a, 79).

Ghose (1927a, 220) has earlier reported from the same locality a var. *epiphyticus* occurring on the barks of the same plant.

### 18. **Chroococcus multicoloratus** Wood

Contributions to the history of the freshwater algae of the United States, 11, pl. 5, fig. 6, 1872; Forti in De Toni, Sylloge Algarum, 5: 11, 1907.

Thallus broad, mucilaginous among other algae; cells spherical, or angular, single or 2–4 (rarely 8) together in a colony, colony oblong; sheath thick, hyaline, not lamellated; contents homogeneous, sometimes minutely granulated; yellow-green or blue-green, yellow-brown or blackish or sometimes tinged with bright lake.

In soils, Lahore (Singh, H. D., 1933, 106).

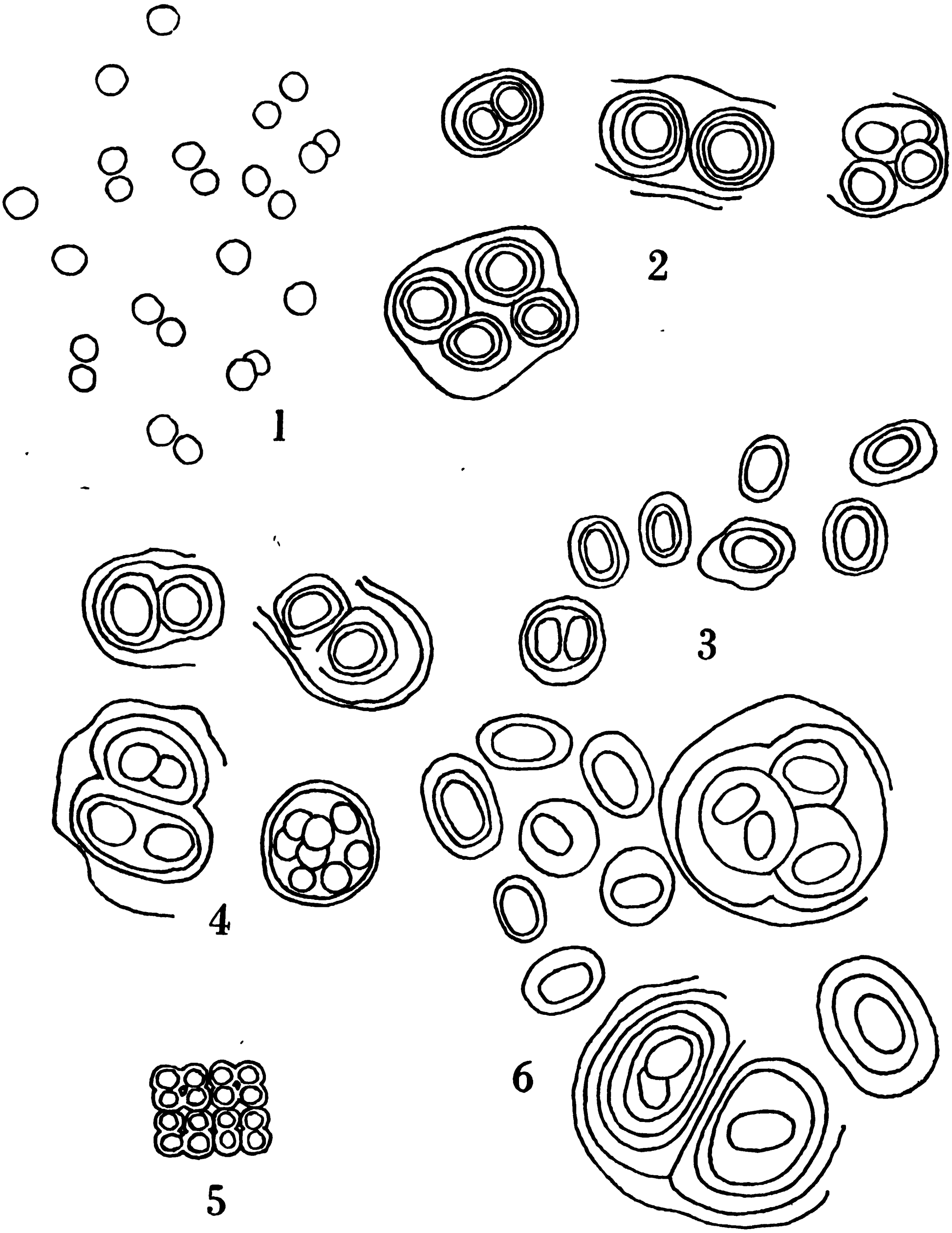

PLATE 23, Figs. 1–6.

1. *Aphanocapsa koordersi* Strom; 2. *Gloeocapsa punctata* Näg.; 3. *Gloeothece samoensis* Wille; 4. *Gloeocapsa kuetzingiana* Näg.; 5. *Merismopedia punctata* Meyen; 6. *Gloeothece samoensis* v. *major* Wille (5 after Kirchner and the rest original).

### 19. **Chroococcus cohaerens** (Bréb.) Näg.

Gatt. einzell. Algen, 46, 1849; Forti in De Toni, Sylloge Algarum, 5: 21, 1907; Frémy, Myxo. d'Afr. équat. franc., 44, fig. 47, 1929; Geitler, Kryptogamenflora, 238, fig. 116e, 1932.

Pl. 26, Figs. 3, 9

Thallus slimy, or gelatinous, blue or dark-green; cells single or up to 2–8 in groups, without envelope 2–5 (–7) μ diam., and with sheath 2.5–7 μ diam., colony 7–15 μ; sheath thin, colorless, unlamellated.

India (?) (Hansgrig *see* De Toni, 1907, 22); in a dirty pond, Ampang, Malay (Biswas, 1929, 22); epiphytic on *Gnetum*, Rangoon (Skuja, 1949, 19).

## SPECIES INQUIRENDA

### **Chroococcus granulosus** Zeller

J. Asiatic Soc. Bengal, 42 (2): 176, 1873; Hedwigia, 12: 169, 1873; Forti in De Toni, Sylloge Algarum, 5: 8, 1907.

Thallus gelatinous, orange colored; cells 4–12 rarely many together, colonies about 25 μ diam.; cells 4.5–7 μ diam., when single about 15 μ diam., spherical or angular; sheath thin, hyaline, when young not conspicuous, later broad.

In alluvial soil, Irrawady, Thyabyaegan, Burma (Zeller, *loc. cit.*; Theobald, 1883, 24).

## GLOEOCAPSA Kützing

Phyc. generalis, 174, 1843.

Cells spherical, 2–8 in colonies, seldom many, with a number of concentric special envelopes; colonies single or many together forming an expanded mass, individual sheaths lamellated or unlamellated, cell division very regularly in three directions, cells in large colonies often with secondary colonies, arranged irregularly; occasionally with nannocytes, resembling *Aphanocapsa*-stage; spores with firm thick walls often formed in a number of species.

Lectotype: *Gl. sanguinea* (Ag.) Kütz. (*see* Geitler, 1942, p. 49).

Nägeli denotes *G. atrata* (Turp.) Kütz., as the type (1849, p. 47). This species is included as a valid species by Forti and Geitler (1932) but the latter feels it may be a colorless form of another species. Wille places it in *Gloeothece rupestris*. Elenkin includes it under *Gloeocapsa montana* Kütz., ampl. Hollerb., f. *typica* Hollerb.

Hollerbach in Elenkin (Monogr. Cyano., Alg., pars spec., 1: 166, 1938; also see in Elenkin, Sovietkaja Botanica, 73, 1934) amends this genus and includes *Chroococcus* in it. Earlier, however, Elenkin (1923) recognises both *Chroococcus* and *Gloeocapsa*. Drouet and Daily (1956, 13) include *Gloeocapsa* (p.p.) under *Coccochloris* Spreng., and include the rest under *Anacystis*.

Large number of investigations on the different characteristics of *Gloeocapsa* has been carried out the significance of which is still not fully comprehended. The nature of the mucilaginous sheath and its coloration have attracted great attention. Brand (1900) studied the variations of *Gloeocapsa alpina* and denotes a large number of developmental stages (Brand, Der Formenkreis von *Gloeocapsa alpina* Näg., Bot. Centralbl., 83: 224, 1900) :—(1) *status pallidus*, with thick colorless sheath, (2) *status coloratus*, with cells with thin prominently colored sheath, (3) *status pendurans*, or spore forming stage, cells with thick membrane lying in common dark colored mucilage and (4) *status solitarius*, gelatinisation of mucilage sheath and the cells lying in a common mucilage. It seems probable one or more of the species now validly recognised as independent may be found to be a stage or stages of one or the other of the rest. *Gloeocapsa compacta* may be a *status siccus* like *Gl. nigrescens*.

Similar studies by Jaag and his associates have caused doubts about the validity of quite a few species. According to Jaag (Neuordnung innerhalb der Gattung *Gloeocapsa*, Verh. Schweiz. naturforsch. Ges., 120: 157–158, 1940), the color of the sheath is a good taxonomic character in *Chrysocapsa* and partly so in *Rhodocapsa* and *Cyanocapsa*. He correlates strong illumination with intense coloration. Similarly thickness of sheath is a direct expression of humidity. Hence he suggests *Gl. ralfsiana* (humid acid form), *Gl. sanguinea*, *Gl. magma* (dry acid form) and *Gl. alpina* (basic substrate form) be combined into one species. In the same year Jaag and Gemsch (Beiträge zur Kenntnis der Hullenfarbstöffe in der Gattung *Gloeocapsa*, Verh. Schweiz. naturforsch. Ges., 120: 158–159, 1940) carried out spectrographic examinations of *Gl. alpina* and *Gl. sanguinea* and concluded that the pigments in the two are chemically identical. They confirm earlier observations of Jaag (1940; *see* also Gemsch, Vergleichende Untersuchungen über Membranfarbung und Membranfarbstöffe in der Gattung *Gloeocapsa* und *Scytonema*, Bot. Schweiz. Ges., 53: 121–192, 1943). Gloeocapsin is the chief pigment but nothing is known regarding its chemical nature although solubility experiments have shown no evidence of the presence of Phycocyanins. In 1945 (Untersuchungen über die Vegetation und Biologie der Algen des nackten Gesteins in der Alpen im Jura und Schweizerischen Mittelland, Beitr. Kryptogamenflora Schweiz, 9 (3): 1–560, pl. 20, 1945) Jaag gives a critical analysis of certain Cyanophycean genera and evaluated such diagnostic features as color of the sheath, cell size, and colony formation. He concludes that some species are only growth forms. He amends *Gl. kützingianum* Näg., to include *Gl. rupestris* and another species of *Gloeocapsa*. Similarly Brand places all forms with violet sheath under *Gl. alpina*. Ercegovic (Acta Bot. Inst. Zagreb, 1: 80, 1925) denotes *Gl. punctata* as the colorless stage of *Gl. dermochroa*.

Nannocyte formation is known in *Gl. granosa* and *Gl. crepidinum* and a profuse formation of nannocytes may lead to the *Aphanocapsa* stage of *Gloeocapsa.*

The development of the sheath is described by Correns (1908).

Spores are known in a number of species. Among the species recorded from the region they have been reported in *Gl. rupestris.*

Drouet and Daily (1956) are of the opinion that the following species of *Gloeocapsa* should be excluded. They have examined the type specimens and have reidentified them: (1) *Gl. granosa* (Carm.) Kütz., ( = *Palmogloea protuberans* (Sm. & Sow.) Kütz.) (2) *Gl. montana* Kütz. ( = P. *protuberans*), (3) *Gl. polydermatica* Kütz. (*P. protuberans*), (4) *Gl. quaternata* (Bréb.) Kütz. ( = *P. protuberans*), and (5) *Gl. crepidinium* Thur. ( = *Entophysalis deusta* (Menegh.) Dr. & D.). A re-examination of the Indian material is absolutely essential to decide the exact taxonomic status of these Indian algae and hence these species are excluded as 'Species Inquirendae.'

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Sheath colorless | 2 |
| 1. | Sheath colored | 10 |
| 2. | Sheath unlamellated | 5 |
| 2. | Sheath lamellated | 3 |
| 3. | Cells without sheath up to 8 μ diam. | 1. *Gl. decorticans* (p. 114) |
| 3. | Cells without sheath narrower | 4 |
| 4. | Cells without sheath 2.5 μ broad | 2. *Gl. gelatinosa* (p. 114) |
| 4. | Cells without sheath 3–5 μ broad | 3. *Gl. polydermatica* (p. 114) |
| 5. | Thallus with calcium impregnation | 4. *Gl. calcarea* (p. 115) |
| 5. | Thallus without calcium impregnation | 6 |
| 6. | Cells without sheath up to 3 μ broad | 7 |
| 6. | Cells without sheath broader, up to 5 μ broad | 8 |
| 7. | Thallus blackish | 5. *Gl. punctata* (p. 115) |
| 7. | Thallus blue-green | 6. *Gl. aeruginosa* (p. 115) |
| 8. | Sheath lamellated | 7. *Gl. atrata* (p. 116) |
| 8. | Sheath unlamellated | 9 |
| 9. | Cells 3–4 μ broad | 8. *Gl. livida* (p. 116) |
| 9. | Cells without sheath 3.5–6.8 μ broad | 9. *Gl. nigrescens* (p. 117) |
| 10. | Sheath yellowish to brownish | 11 |
| 10. | Sheath red, brownish red or orange | 16 |
| 10. | Sheath violet | 19 |
| 11. | Saltwater form | 10. *Gl. crepidinum* (p. 117) |
| 11. | Freshwater species | 12 |
| 12. | Cells without sheath 6–11 μ broad | 11. *Gl. rupestris* (p. 117) |
| 12. | Cells smaller | 13 |
| 13. | Sheath lamellated | 14 |
| 13. | Sheath unlamellated | 15 |
| 14. | Cells without sheath 1.5–2 μ broad | 12. *Gl. fuscolutea* (p. 118) |
| 14. | Cells without sheath 5–10 μ broad | 13. *Gl. pleurocapsoides* (p. 118) |

15. Cells without sheath 1–3 μ broad .................... 14. *Gl. dermochroa* (p. 118)
15. Cells without sheath 3–5 μ broad .................... 15. *Gl. kuetzingiana* (p. 118)
15. Cells without sheath 4 μ broad ...................... 16. *Gl. luteofusca* (p. 119)
    16. Cells without sheath 2–4 μ broad .................................. 17
    16. Cells without sheath 4–7 μ broad .................................. 18
17. Sheath more or less yellowish ..................... 17. *Gl. stegophila* (p. 119)
17. Sheath more or less reddish ....................... 18. *Gl. quaternata* (p. 120)
    18. Sheath lamellated ........................... 19. *Gl. magma* (p. 120)
    18. Sheath unlamellated ......................... 20. *Gl. sanguinea* (p. 121)
19. Sheath lamellated ................................. 21. *Gl. coracina* (p. 121)
19. Sheath unlamellated ................................................. 20
    20. Cells without sheath 2–2.5 μ broad .......... 22. *Gl. compacta* (p. 121)
    20. Cells without sheath 3.5 μ broad ............ 23. *Gl. violacea* (p. 123)

### 1. **Gloeocapsa decorticans** (A. Br.) Richter

*ex* Wille, Nyt. Mag. Naturvid., 62: 186, 1925; Geitler, Kryptogamenflora, 184, fig. 83b, 1932.

Pl. 24, Fig. 9

Cells spherical or sometimes oval, blue-green, single or up to 2–4 together; single cells with 19 × 21 μ without sheath 6 × 8 μ, in a two celled stage with sheath 22 × 30 μ, without sheath up to 12 μ long; sheath colorless, thick, distinctly lamellated.

In cultures of garden soil, Allahabad (Mitra, 1951, 360).

### 2. **Gloeocapsa gelatinosa** Kütz.

Phyc. generalis, 174, 1843; Tab. Phycologicae, 1: pl. 20, fig. 6b, 1846; Forti in De Toni, Sylloge Algarum, 5: 54, 1907; Frémy, Myxo. d'Afr. équat. franc., 47, fig. 52, 1929; Geitler, Kryptogamenflora, 187, 1932.

Pl. 27, Fig. 6

Cells without sheath about 2.5 μ and with sheath 6.2–10 μ diam., blue-green; colonies about 25 μ diam.; sheath colorless, seemingly thin, when old lamellated.

On the barks of *Hevea brasiliensis*, Kaisering Island, Burma (Ghose, 1927c, 246); on the sides of a cemented drain, Calcutta in India (Banerji, 1936, 298).

The original type specimen of Kützing has been found to be an *Aphanothece* (*A. bullosa*). Hence this species has to be excluded from *Gloeocapsa* and the identity of the Indian material is doubtful.

### 3. **Gloeocapsa polydermatica** Kütz.

Tab. Phycologicae, 1: 15, pl. 20, fig. 3, 1846; Species Algarum, 208, 1849; Forti in De Toni, Sylloge Algarum, 5: 51, 1907; Geitler, Kryptogamenflora, 185, fig. 83c, e, 1932.

Pl. 25, Fig. 1

Thallus mucilaginous, compact; cells spherical, without sheath 3–4.5 µ diam., blue-green; sheath colorless very thick, as thick as protoplast, very distinctly and many times lamellated.

On wet rocks and moist lawns.—Dawna Hills (Carter, 1926, 267); Lahore in Pakistan (Ghose, 1919, 9).

Ghose describes the cells as 5 µ diam.

### 4. **Gloeocapsa calcarea** Tilden

Minn. Bot. Studies, ser. 2, 1: 29, 1898; Forti in De Toni, Sylloge Algarum, 5: 40, 1907; Geitler, Kryptogamenflora, 187, fig. 83a, 1932.

Pl. 24, Fig. 6

Thallus with calcium incrustation; cells with or without individual sheath, 6–9 µ diam., blue-green; sheath colorless often thin; colonies 25–50 µ in diam., with 4–16 cells.

In slow sand filters, Madras, (Ganapathi, 1940a, 246).

### 5. **Gloeocapsa punctata** Näg.

*ex* Kützing, Species Algarum, 22, 1849; Nägeli, Gatt. einzell. Algen, 51, pl. 1F, fig. 6, 1849; Forti in De Toni, Sylloge Algarum, 5: 55, 1907; Frémy, Myxo. d'Afr. équat. franc., 47, 1929; Geitler, Kryptogamenflora, 189, 1932.

Pl. 23, Fig. 2

Thallus gelatinous, light blue-green; cells without sheath 0.7–1.5 (–2.8) µ diam., with sheath 3.5–7 µ broad, blue-green; sheath thick, colorless, unlamellated or scarcely lamellated; cells 2–16 in groups or colonies, about 25 µ diam.

In a cemented water reservoir, Benaras (Rao, C. B., 1937b, 344); also on the sides of cement tub, Madras ( ! ).

The Madras plant has broader cells (2.6–3.9 µ broad).

Playfair (Biol. Richmond river, p. 135, pl. 6, fig. 21, 1914) places it as a variety of *Coelosphaerium kützingianum*, var. *punctatum* (Kütz.) Playfair.

### 6. **Gloeocapsa aeruginosa** (Carm.) Kütz.

Phyc. gene., 174, 1843; Phyc. germ., 151, 1845; Tab. Phycologicae, 1: pl. 21, fig. 2, 1846; Species Algarum, 218, 1849; Forti in De Toni, Sylloge Algarum, 5: 55, 1907.

Thallus crustaceous, granulose or cartilaginous, mucilaginous; cells 2–3 μ broad, with sheath 4.8 μ broad, in colonies; colonies spherical, 16–50 μ diam., sheath indistinctly lamellated.

On walls, Berkuda Island, Chilka lake, Orissa (Biswas, 1924, 361); forming blue-green crusts on canal banks, salt lakes, Calcutta (Biswas, 1926, 16), planktonic in a lake, Hyderabad (Deccan) (Ghousuddin, 1936, 149) and in the River Hooghly (Biswas, 1942, 198).

Biswas (1926, 16) records the cells as 2–4 μ diam.

Geitler (1932, 189) considers this as the nannocyte stage of another species.

### 7. **Gloecapsa atrata** (Turp.) Kütz.

Phyc. generalis, 172, 1843; Tab. Phycolcgicae, 1: pl. 21, fig. 4, 1846; Forti in De Toni, Sylloge Algarum, 5: 57, 1907; Wille, Monogr. Chroococcaceen, p. 185, pl. 9, fig. 18, Geitler, Kryptogamenflora, 188, 1932.

Pl. 24, Fig. 8

Thallus crustaceous, mucilaginous, blackish; cells without sheath 3.5–4.5 (–5) μ diam., with sheath 9–14.5 μ diam., pale blue-green, mostly many in a colony; sheath colorless or pale bluish, thick, unlamellated or indistinctly lamellated.

On the sides of moist walls and on the rocky beds of rivers.—N. India (Turner, 1892, 12), Benaras (Bharadwaja, 1935, 97), Bombay (Dixit, 1936, 95) and Calcutta (Banerji, 1936, 298) in India and in Rangoon, in Burma (Ghose, 1927b, 238).

In the Benaras form (Bharadwaja, 1935) the colonies are up to 50 μ diam., and the cells with sheath are 5.2–14.5 μ broad.

### 8. **Gloeocapsa livida** (Carm.) Kütz.

Tab. Phycologicae, 1: 17, pl. 21, fig. 5, 1846; Species Algarum, 220, 1849; Forti in De Toni, Sylloge Algarum, 5: 56, 1907.

Pl. 27, Fig. 8

Thallus mucilaginous, first rounded or lobed, later expanded, hyaline, greenish to olive brown in color; cells small, with sheath 6–8 μ diam. and without sheath 3–4 μ diam., in colonies of 16–94 μ diam.; sheath light bluish, hyaline; contents densely bluish green.

India (Hansgirg, see De Toni, 1907, 56); Shembaganur (Frémy, 1942, 21).

### 9. **Gloeocapsa nigrescens** Näg.

in Rabenhorst, Alg. Sachs., 63, 629, 1857; Fl. Eur. Alg., 2; 40, 1865; Forti in De Toni, Sylloge Algarum, 5: 42, 1907 (*non* Correns).

Pl. 24, Figs. 15, 17

Thallus crustaceous, thin, blackish; cells spherical, without sheath 3.3–6.8 μ diam., and with sheath 12–13.5 μ diam., in colonies of 30–125 μ diam., uniting laterally; sheath broad, not lamellated, light purple, sometimes intense purple or colorless; contents blue-green; spores with a smooth thin membrane, 5–7 μ in diam., many in a homogeneous sheath.

Rangoon in Burma (Skuja, 1949, 17).

### 10. **Gloeocapsa crepidinum** Thuret

in Bornet and Thuret, Notes Algologiques, 1: 1, pl. 1, fig. 1–3, 1876; Forti in De Toni, Sylloge Algarum, 5: 44, 1907; Geitler, Kryptogamenflora, 190, figs. 85, 86, 1932; Frémy, Cyano. cotes d'Eur., 26, pl. 5, fig. 12, 1933.

Pl. 27, Figs. 4, 5

Thallus gelatinous, olivaceous, when dried blackish, gelatinous, soft; cells in groups of 2–4, rarely more, colonies spherical or oval, 12–24 μ diam., closely arranged in the peripheral regions and loosely arranged in the middle, cells without sheath 4–8 μ in diam.; with a thin yellowish to brownish sheath in the outer regions and colorless or diffluent in the sheaths inside, sheaths unlamellated; often with nannocyte formation, nannocytes 2.5–3.5 μ diam.

Poona (Schmidle, 1900b, 162).

### 11. **Gloeocapsa rupestris** Kütz.

Tab. Phycologicae, 1: 17, pl. 22, fig. 2, 1846; Species Algarum, 223, 1849; Forti in De Toni, Sylloge Algarum, 5: 46, 1907; Frémy, Myxo. d'Afr. équat. franc., 50, fig. 56, 1929; Geitler, Kryptogamenflora, 194, figs. 88e, 89, 1932.

Thallus brownish, crustaceous; cells without sheath 6–9(–11) μ in diam., blue-green; sheath yellow to brown, outer daughter colonies often pale yellow to nearly colorless, very distinctly lamellated; colonies 15–75 μ in diam.; spores with firm thin blackish brown wall, more or less 15 μ diam.

On submerged branches near Hooghly, Calcutta (Prain, 1905, 332) and floating in masses in a shallow pond, Calcutta (Banerji, 1936, 298) in India; on moist grounds in lawns, Lahore in Pakistan (Ghose, 1924, 336).

Ghose described the cells as 3–6 μ diam., and Banerji gives the breadth of the cells with sheath as 9–20 μ diam. Martens (1870b, 260) has described a form (f. *pallida*) growing on the walls of the Sibpur Bot. gardens, Calcutta.

### 12. **Gloeocapsa fusco-lutea** Näg.

in Kützing, Species Algarum, 229, 1849; Nägeli, Gatt. einzell. Algen, 57, 1849; Forti in De Toni, Sylloge Algarum 5: 47, 1907; Geitler, Kryptogamenflora, 194, fig. 88b, 1932.

Cells without sheath 1.5–2 μ diam., with sheath 4.5–5.5 μ diam., pale blue-green; sheath yellowish to brown, broad, mostly lamellated; colonies up to 50 μ diam.

India (Hansgirg, *see* De Toni, 1907, 47).

### 13. **Gloeocapsa pleurocapsoides** Novacek

Prace Moravske Prirodo Moravya a Slezka Oddel, Bot., 7: 1, 1929; Skuja, Zur Süsswasseralgenflora Burmens, 17, pl. 1, figs. 3–5, 1949.

Pl. 24, Fig. 3

Colony microscopically small, more or less roundish or irregular, dull olive green, brownish or blackish brown; cells olive colored or pale blue-green, homogeneous, granular; cells 5–10 μ in diam., elongated or angular, closely arranged; sheath thin, firm, simple, colored yellowish brown or brownish in the peripheral part 2–3 μ thick and lamellated, 3–4 lamellae.

Rangoon, in Burma (Skuja *loc. cit.*).

### 14. **Gloeocapsa dermochroa** Näg.

in Kützing, Species Algarum, 224, 1849; Nägeli, Gatt. einzell. Algen, 51, 1849; Forti in De Toni, Sylloge Algarum, 5: 45, 1907; Frémy, Myxo. d'Afr. équat. franc., 49, fig. 54, 1929; Geitler, Kryptogamenflora, 194, fig. 90, 1932.

Colonies of 4–8–16 cells, about 25 μ diam.; cells without sheath 1.5–3 μ diam., with sheath up to 8 μ diam., blue-green; sheath yellow to brown, not lamellated; spores with a thin, firm, membrane.

In the environs of Shembaganur, Madurai dist. (Frémy, 1942, 21); and Rangoon in Burma (Skuja, 1949, 16).

Ercegovic included this as a form of *Gloeocapsa biformis* (*see* also Skuja, 1949, 17).

### 15. **Gloeocapsa kuetzingiana** Näg.

Gatt. einzell. Algen, 50, 1849; Rabenhorst, Fl. Eur. Alg., 2; 46, 1865; Forti in De Toni, Sylloge Algarum, 5: 47, 1907; Geitler, Kryptogamenflora, 194, fig. 91a, 1932.

Pl. 23, Fig. 4 & Pl. 24, Fig. 12

Thallus thin, soft, brownish or blackish; cells densely aggregated in colonies up to 150 μ diam.; cells without sheath 3–4 μ diam., with sheath 4–7.5 μ diam., blue-green; sheath yellow to brown, not lamellated.

On the wet walls of a well, Madras ( ! ).

The Madras alga is somewhat different:—Cells without sheath (2.6–) 3.9–5 μ diam. and with sheath 5.2–6.6 (–7.9) μ broad and the sheath is occasionally lamellated. (Pl. 23, Fig. 4).

### 16. **Gloeocapsa luteo-fusca** Martens

ex Wille, Vorarbeiten zu einer Monographie der Chroococcaceen, Nyt. Mag. Naturvid., 62: 191, pl. 11, fig. 25, 1925.

Pl. 24, Fig. 16

Thallus compact, expanded leathery, blackish to olive green in color; cells with a colorless sheath at first, later dull-brown or yellowish, 6–7 μ long, 4 μ broad, with sheath 16 μ long and 12 μ broad.

Along dried up mud of Mayzeleechoung, Pegu, Northern Yomah, Burma (Martens, 1871b, 462; also Theobald, 1883, 21).

### 17. **Gloeocapsa stegophila** (Itzigs.) Rabenh.

Krypto.-fl. Sachsen, 1: 72, 1863; Forti in De Toni, Sylloge Algarum, 5: 49, 1907; Geitler, Kryptogamenflora, 197, fig. 91b, 1932.

Cells without sheath 3–4 μ, with sheath 4.5–8 μ diam.; 4–32 cells in globose groups, 50–140 μ diam.; blue-green; sheath golden to orange yellow to red, mostly unlamellated; spores with a dull reddish brown, thin firm membrane.

Not recorded.

The type has not been reported from the region. Rao, C. S., (1940, 126) describes a form.–Colony 9–19 (–22) μ diam., cells 3–5.5 μ broad, sheath 1.5–2 μ thick, outlines of sheath rugged.

### Var. **crassa** Rao, C. B.

Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6; 344, fig. 1D, 1937b.

Pl. 25, Fig. 3

Thallus soft, yellowish brown; cells spherical, subspherical or elongated, 4–6.4 μ broad or rarely 6.4–9.6 μ long, commonly single or in colonies of 2–4;

sheath golden yellow, sometimes striated; colony with sheath 8–15 μ broad and 9.6–19.2 μ long, sheath up to 3.2 μ thick.

On moist soil, Benaras (Rao, C. B., *loc. cit.*).

### 18. **Gloeocapsa quaternata** (Bréb.) Kütz.

Tab. Phycologicae, 1: 15, pl. 20, fig. 1, 1846; Forti in De Toni, Sylloge Algarum, 5: 52, 1907; Frémy, Myxo. d'Afr. équat. franc., 47, fig. 53, 1929; Geitler, Kryptogamenflora, 197, fig. 91e, 1932.

Pl. 20, Fig. 9

Thallus pale green or blackish, brownish or yellowish, expanded or forming tubercles; cells without sheath 3–4.5 μ diam., rarely 5 μ diam., with sheath 7–11 μ in diam., blue-green; sheath often lamellated, colorless to red; cells single, 2–4, sometimes up to 8 in colonies, colonies 11–22 μ in diam.

On moist soil, Lahore in Pakistan (Ghose, 1924, 336); in filter beds, Faridpur, Berhampur (Bruhl and Biswas, 1922, 3), road slimes, Calcutta (Biswas, 1925, 3) and on moist subaerial habitats, Calcutta (Banerji, 1936, 298).

### 19. **Gloeocapsa magma** (Bréb.) Kütz.

Tab. Phycologicae, 1: 17, pl. 22, fig. 1, 1846; Forti in De Toni, Sylloge Algarum, 5; 35, 1907; Frémy, Myxo. d'Afr. équat. franc., 50, fig. 57, 1929; Geitler, Kryptogamenflora, 198, fig. 93, 1932.

Pl. 24, Fig. 13

Colonies spherical or irregularly arranged, 30–60 (–70) μ, mostly 45 μ diam., seldom larger, and up to 300 μ diam., colorless or red or brown with 2.5 cm. thick cuticle like sheath; cells spherical or angular, 3–7 μ diam., blue-green, mostly with a thin, 0.5–1.5 μ broad, colored individual sheath and a very slimy, colored or colorless mostly unlamellated sheath, which at the margins develops a thin (0.5 μ br.) cuticle like outermost layer; cells with sheath 7.5–16 μ diam.; spores up to 10.5 μ broad, seldom up to 13 μ diam., with a thin firm dull reddish brown sheath, often with one or more broader sheaths enclosed, with 2 μ thick colored outermost layer; sheath often rough in *Aphanocapsa*-stage.

In slow sand filters, Madras (Ganapathi, 1940, 246) and Rangoon, in Burma (Skuja, 1949, 17).

Wille (1919) includes in this *Gl. itzigsohnii.* Hollerbach (Not. Syst. Inst. Crypto. Horti Bot. Reipubl. Ross., 3, 1924) gives a good account of the variations in this species.

### 20. **Gloeocapsa sanguinea** (Ag.) Kütz.

Phyc. generalis, 175, 1843; Tab. phycologicae, 1: pl. 22, 1846; Forti in De Toni, Sylloge Algarum, 5: 36, 1907; Geitler, Kryptogamenflora, 202, fig. 94a, 1932.

Pl. 27, Fig. 7

Cells without sheath 4.5–6.5 μ diam., with sheath up to 13 μ diam., pale blue-green, colonies 25–50 rarely up to 140 μ diam., sheath present in the inside of the colony dull bluish red and in the outer portions dull red or colorless, homogeneous.

Epiphytic on *Anacardium occidentale*, Rangoon, Burma (Skuja, 1949, 18).

### 21. **Gloeocapsa coracina** Kütz.

Phyc. generalis, 174, pl. 6, fig. I, 1, 1843; Tab. Phycologicae, 1: pl. 21, fig. 3, 1846; Forti in De Toni, Sylloge Algarum, 5: 56, 1907.

Pl. 24, Fig. 11

Thallus crustaceous, lubricous; cells single, round small, with sheath 6–14 μ and without sheath about 3 μ broad, single or in groups of 9–75 μ diam., laterally uniting; sheath light violaceous, distinctly lamellated; contents homogeneous, blue-green.

India (Hansgirg, *see* De Toni, 1907, p. 56).

Geitler (1932, p. 207) following Brand places this species under *Gl. alpina* Näg. em. Brand. An examination of Hansgirg's Indian material is needed to place this species properly.

### 22. **Gloeocapsa compacta** Kütz.

Tab. Phycologicae, 1: 24, pl. 36, fig. 4, 1846; Species Algarum, 22, 1849; Geitler, Kryptogamenflora, 207, fig. 101, 1932; Frémy, Cyano. cotes d'Eur., 27, pl. 5, fig. 3, 1933.

Pl. 24, Fig. 7

Thallus reddish brown, compact; cells without sheath mostly 2–2.5 μ diam., blue-green; sheath unlamellated, dull reddish violet to colorless with many daughter colonies, sometimes a dull brownish firm individual envelope present, with envelope up to 3.5 μ diam.; colonies up 12–20 μ diam.

Rangoon in Burma (Skuja, 1949, 16).

The Burmese alga has a spherical to irregular thallus and the cells without sheath are 2.5–3 μ broad.

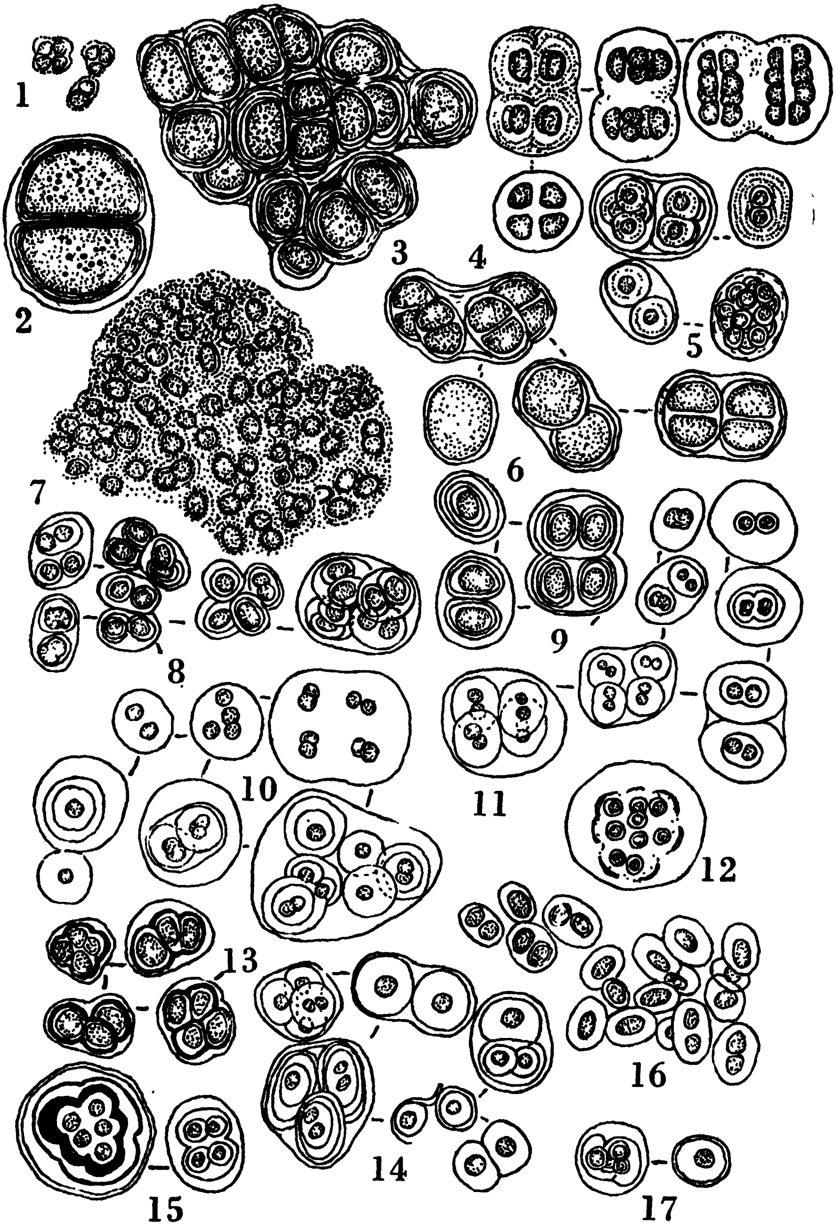

PLATE 24, Figs. 1–17.

1. *Chroococcus minor* (Kütz.) Näg. (after Skuja); 2. *C. turgidus* v. *maximus* Nygaard (after Skuja); 3. *Gloeocapsa pleurocapsoides* Nck. (after Skuja); 4. *Chroococcus minutus* (Kütz.) Näg. (after Skuja); 5. *C. varius* A. Br. (after Hollerbach in Elenkin as *Gloeocapsa varius*); 6. *Gloeocapsa calcarea* Tilden (after Hollerbach in Elenkin); 7. *G. compacta* Kütz. (after Skuja); 8. *G. atrata* (Turp.) Kütz. (after Wille); 9. *G. decorticans* (A. Br.) Richter (after Wille); 10. *G. granosa* (Berk.) Kütz. (after Wille); 11. *G. coracina* Kütz. (after Wille); 12. *G. kuetzingiana* Näg. (after Wille); 13. *G. magma* (Bréb.) Kütz. (after Wille); 14. *G. montana* Kütz. (after Wille); 15, 17. *G. nigrescens* Näg. (after Wille); 16. *G. luteofusca* Martens (after Wille).

Richter (in Hansgirg, Prodromus, 149, 1892; also Forti in De Toni, Sylloge Algarum, 5: 40, 1907) places this as a variety under *Gloeocapsa violacea* (Corda) Rabenh.

### 23. **Gloeocapsa violacea** (Corda) Rabenh.

Fl. Eur. Alg., 2: 41, 1865; Forti in De Toni, Sylloge Algarum, 5: 39, 1907; Geitler, Kryptogamenflora, 209, 1932.

Cells spherical, without sheath about 3.5 μ diam., with sheath 10–17 μ diam., the sheath violet, partly diffluent; colony mucilaginous, about 100 μ diam.

Igatpuri, Bombay (Schmidle, 1900b, 162).

## SPECIES INQUIRENDAE

### **Gloeocapsa granosa** (Berk.) Kütz.

Tab. Phycologicae, 1: 36, fig. 8, 1849; Forti in De Toni, Sylloge Algarum, 5: 53, 1907.

Stratum compact gelatinous, more or less cartilaginous, granulose, green or olivaceous, or yellowish, more or less expanded; cells spherical to oblong, with sheath 7–8 μ broad, without sheath 3–5 μ broad, generally in colonies of 2–4, colonies 18–60 μ broad; sheath broad, indistinctly lamellated, nearly colorless, contents homogeneous, to granular, pale blue-green.

Type form not recorded.

Gonzalves (Gonzalves, 1947, 24) recorded a form of the species from the hot springs at Vajreshwari growing at a temperature of 34°C.

### **Gloeocapsa montana** Kütz.

Phyc. gene., 173, 1843; Tab. phycologicae, 1: 15, pl. 19, fig. 11, 1846; Species Algarum, 218, 1849; Forti in De Toni, Sylloge Algarum, 5: 50, 1907.

Thallus amorphous, broad, mucilaginous, pale yellowish, or light green in color; cells spherical or subspherical, with sheath 4–10 μ broad and without sheath 2–5 μ broad, single or two together in a colony, colony 13–28 μ broad; sheath lamellated, colorless, outer lamellae diffluent; contents more or less opaque, homogeneous, finely granular, pale blue-green.

On dripping rocks at Therria, the Khasia Hills, Assam (Biswas, 1934, 10); on a moist brick in a fern house, Calcutta, Bengal (Banerji, 1936, 297).

### **Gloeocapsa conglomerata** Kütz.

Tab. Phycologicae, 1: 16, pl. 20, fig. 8, 1846; Species Algarum, 216, 1849; Forti in De Toni, Sylloge Algarum, 5: 56, 1907.

Thallus gelatinous, subgranular, olive green; cells with sheath 7–10 μ diam. without sheath 3–6 μ in diam., in groups of about 22–45 μ diam., broadly united, spherical colonies; sheath thick, colorless, unlamellated or slightly lamellate; contents blue-green, sometimes brownish; nannocytes present.

On damp soil or on barks of trees, Lahore in Pakistan (Ghose, 1924, 336); Rangoon in Burma (Ghose, 1927a, 221; 1927e, 80; Skuja, 1949, 16).

Ghose observed that the thallus is thin, gelatinous and dark olive green when fresh and on drying up becomes brownish. Geitler (1932, 189) considers this as a nannocyte stage and not an independent species.

### SPECIES EXCLUDENDA

***Gloeocapsa kurziana*** Martens.—Bot. gardens, Sibpur, Calcutta (*see* Prain, 1905, p. 332).

## GLOEOTHECE Näg.

Gatt. einzell. Algen, 57, 1849.

Cells cylindrical to ellipsoidal, straight or bent, not attenuated at the ends, but broadly rounded, in small colonies or forming large thallus, division of cells at right angles to the longitudinal axis, sometimes the daughter cells divide in all the three directions; sheath structure and colony structure as in *Gloeocapsa*; nannocytes present.

Type species: *Gloeothece linearis* Näg.

Geitler (1942, 53) says that typical nannocyte formation is not seen and that the repeated division leading to the formation of many nearly spherical cells in a common envelope are often seen to be very much similar to the nannocyte formation. Spore formation has been recently reported by Skuja (1949, p. 18; *see* Pl. 5, Fig. 14).

Movements of cells is known in *Gloeothece linearis* (Kongisser, Zur Kenntnis der Bewegungen einzelligen Cyanophyceen, J. Bot. URSS, 17: 379–362, 1932).

Form variations in *Gloeothece rupestris* in relation to physical and chemical changes has been investigated by Brunnthaler (Sitzb. K. Akad. Wiss. Wien, Math.-Naturw. Kl., 118, 1909).

Among the species recorded from India two species, based on examination of the type specimens, have been excluded by Drouet and Daily (1956):—(1) *Gloeothece distans* Stizenb. ( = *Palmogloea protuberans* (Sm. and Sow.) Kütz.) and (2) *Gl. membranacea* (excluded as a bacteria based on a topotype material investigation, *see* Drouet and Daily, 1956, 143). An examination of the Indian material is called for.

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Mucilage envelopes colored | 2 |
| 1. | Mucilage envelopes colorless, only rarely yellowish | 4 |
| 2. | Envelopes yellow to brown | 3 |
| 2. | Envelopes reddish to rose | 2. *Gl. rhodochlamys* (p. 125) |
| 3. | Cells without envelopes 4–5.5 μ broad and up to 11 μ long | 1. *Gl. fusco-lutea* (p. 125) |
| 3. | Cells mostly longer | 3. *Gl. rupestris* (p. 127) |
| 4. | Cells without envelope 2.5–4.5 μ broad | 5 |
| 4. | Cells without envelope 4–6 μ broad | 6 |
| 5. | Cells cylindrical, up to three times as long as broad | 4. *Gl. palea* (p. 127) |
| 5. | Cells ellipsoidal | 5. *Gl. samoensis* (p. 128) |
| 6. | Cells up to 10 μ long, ellipsoidal | 7 |
| 6. | Cells up to 15 μ long, ellipsoidal to cylindrical | 3. *Gl. rupestris* (p. 127) |
| 7. | Cells without envelope 4.5–5.5 μ broad | 6. *Gl. membranacea* (p. 128) |
| 7. | Cells 5–6 μ broad | 5. *Gl. samoensis* v. *major* (p. 128) |

### 1. **Gloeothece fusco-lutea** Näg.

Gatt. einzell. Algen, 58, 1849; Forti in De Toni, Sylloge Algarum, 5: 66, 1907; Geitler, Kryptogamenflora, 216, fig. 104a, 1932.

Pl. 25, Fig. 5

Thallus mucilaginous, expanded blue-green to brown; cells ellipsoidal to cylindrical, without envelope 4.5–5.5 μ broad, 1½–2½ times as long as broad, mostly 4–8 seldom 16–32 together, cells with primary and secondary mucilaginous envelopes, sheath brown.

In the environs of Shembaganur, Madurai dist. (Frémy, 1942, 21).

Geitler thinks that this species is the same as *Gloeothece rupestris*. Between the two species there does not appear to be any great difference.

### 2. **Gloeothece rhodochlamys** Skuja

Zur Süsswasseralgenflora Burmas, 18, pl. 1, figs. 6, 7, 1949.

Pl. 25, Figs. 13, 14

Thallus at first minute and microscopic, more or less rounded, later forming an expanded gelatinous thallus, blue green, red or purple; cells ellipsoidal to short cylindrical with rounded ends, 2–3 μ broad and 3–5.5 μ long, protoplasm homogeneous with a olive-green or olivaceous individual envelopes, distinct, when young 0.5 μ thick, lamellate, red or purple or reddish brown; in adult colonies with 4–16 cells in each envelope, with envelope 10–20 μ broad; spores globose or ellipsoidal, 5.5 μ broad and 6–8 μ long, membrane divided at the equatorial line, mesospore 0.25–0.5 μ thick, brown and delicately papillate, epispore gelatinous and granular, red to purple, endospore hyaline, and homogeneous.

Kyauktan and near it in Burma (Skuja, *loc. cit.*).

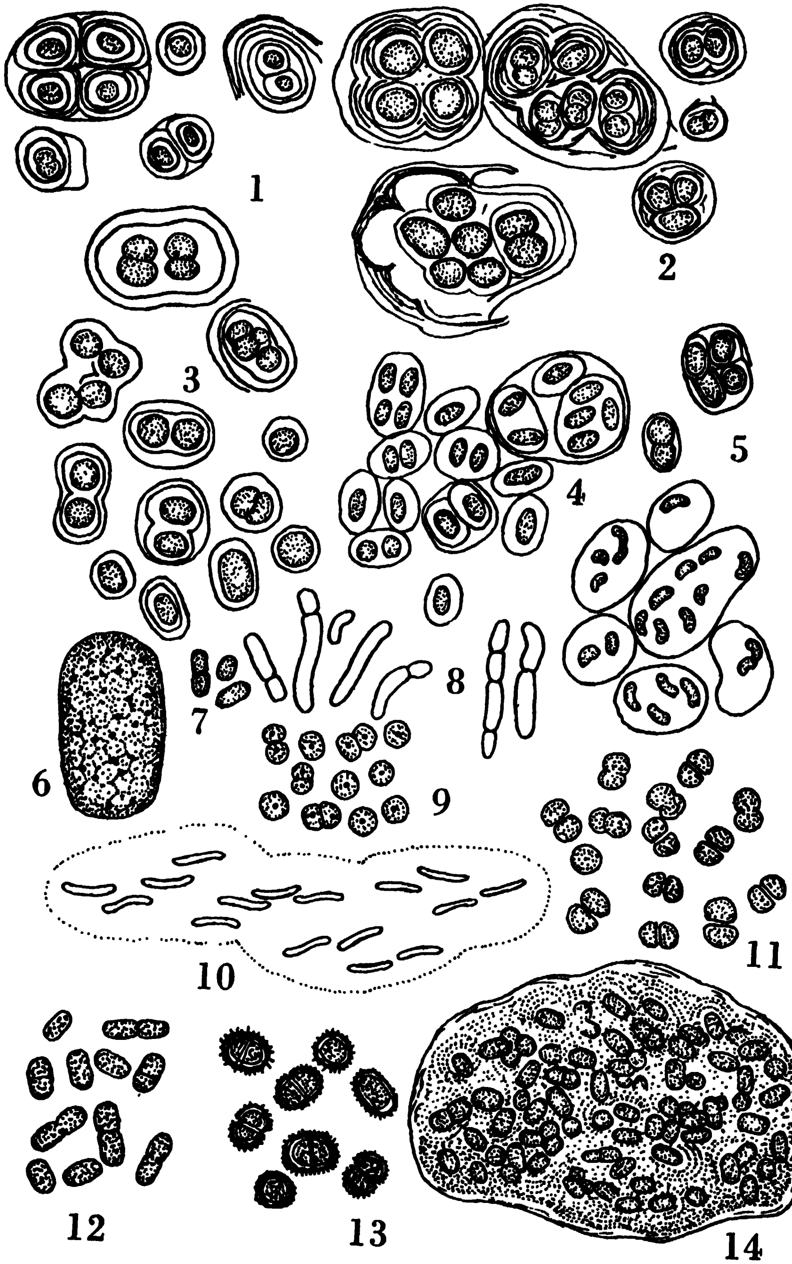

PLATE 25, Figs. 1-14.

1. *Gloeocapsa polydermatica* Kutz. (after Wille); 2. *G. stegophila* (Itzigs.) Rabenh. (after Wille); 3. *G. stegophila* v. *crassa* Rao, C. B. (after Rao); 4. *Gloeothece rupestris* (Lyngb.) Born. (after Cooke); 5. *G. fuscolutea* Näg. (after Geitler); 6. *Synechococcus aeruginosus* Näg. (after Geitler); 7. *S. elongatus* Näg. (after Geitler); 8. *S. elongatus* Näg. (after Geitler); 9. *Synechocystis aquatilis* Sauv. (after Sauvageau); 10. *Rhabdoderma gorskii* Wolosz. (after Woloszynska); 11. *Synechocystis pevalekii* Erceg. (after Ercegovic); 12. *Synechococcus aeruginosus* Näg. (after Frémy); 13, 14. *Gloeothece rhodochlamys* Skuja (after Skuja).

### 3. **Gloeothece rupestris** (Lyngb.) Bornet

Alg. de Schousb., Mem. Soc. Sci. Nat. Math. de Cherbourg, 28: 177, 1892; Forti in De Toni Sylloge Algarum, 5: 63, 1907; Frémy, Myxo. d'Afr. équat. franc., 52, fig. 61, 1929; Geitler, Kryptogamenflora, 221, 1932.

Pl. 25, Fig. 4

Cells ellipsoidal to cylindrical, without envelope 4–5.5 (–6) μ broad, 1.5–3 times as long as broad, with envelope 8–12 μ broad, contents mostly blue-green, 2–4 rarely 8 together in oval to subglobose colonies, colonies 25–41 μ diam., envelopes colorless or brownish at the peripheries, lamellated or unlamellated; inside the colonies diffluent.

Subaerial.—Trivandrum (Parukutty, 1940, 118); Shembaganur in Madurai dist. (Frémy, 1942, 19).

Parukutty describes the cells in the Trivandrum material as 6.6–9 μ long and 4–4.5 μ broad.

### Var. **maxima** West

J. Roy. micr. Soc. : 743, 1892; Skuja, Süsswasseralgenflora Burmas, 19, 1949.

Cells cylindrical with rounded ends, 9–10 μ broad and 14–16 μ long, with large granules, mucilage sheath thick, cells with sheath 13–20 × 18–30 μ.

Epiphytic in Mandalay and in running soiled trench water, Rangoon, in Burma (Skuja, 1949, 19).

Skuja's Burmese alga differs from West's alga in the cells being only 6–7 × 10–19 μ in size. Nor does it agree with Bornet's description. Following Skuja's observation that it comes near var. *maxima*, the Burmese alga is tentatively placed here.

### 4. **Gloeothece palea** (Kütz.) Rabenh.

Fl. Eur. Alg., 2: 60, 1865; Forti, in De Toni, Sylloge Algarum, 5: 62, 1907; Geitler, Kryptogamenflora, 218, 1932.

Thallus mucilaginous, mostly blue-green; cells long cylindrical, without envelope 2.5–4.5 μ broad, 1½–3 times as long as broad, with envelope 8–12 μ broad, blue-green or nearly colorless; individual mucilaginous envelopes colorless or partly colored yellowish, not lamellated, nannocytes present.

Aquatic, epiphytic, Rangoon and Mandalay in Burma (Skuja, 1949, 18).

Skuja has earlier described the same species with partly lamellated envelopes. The Burmese alga, however, has unlamellated envelopes but differs from the type in small dimensions (without envelopes 2–2.5 μ broad, 3–4 μ long, blue-green to olive-green, with envelope 8 μ long and 6 μ broad). Skuja has also described the formation of nannocytes in this alga.

### 5. **Gloeothece samoensis** Wille

Süsswasseralg. Samoa-Ins., Hedwigia, 53: 144, 1913; in Rechinger, Bot. and Zool., Ergebn. Samoa und Solomoninseln, Süsswasseralgen, 6, pl. 1, fig. 3, 1915; Geitler, Kryptogamenflora, 219, 1932.

Pl. 23, Fig. 3

Cells ellipsoidal, without sheath 4–5 μ broad, 8 μ long, cells yellowish or bluish green, in round colonies, often many uniting, mostly 2–4 in a common envelope, envelope colorless, unlamellated.

On dripping rocks, Kunnakudi ( ! ) and on moist soil, Madras ( ! ).

The Indian form here reported is slightly different (cells ellipsoidal, 3.9–5.2 (–6.6) μ broad and 3.9–6.6 μ long; envelopes sometimes colored brownish).

### Var. **major** Wille

in Rechinger, *loc. cit.*, 6, pl. 1, fig. 4, 1915; Geitler, Kryptogamenflora, 220, 1932.

Pl. 23, Fig. 6

Cells without envelope 5–6 μ broad and 8–10 μ long.

On the inner walls of a well, Madras ( ! ).

The Madras form is somewhat different (Cells without envelopes 3.9–6.6 μ broad, with envelope 6.6–10.5 μ broad and 6.2–9.2 μ long; sheath hyaline and stratified; nannocytes present).

### 6. **Gloeothece membranacea** (Rabenh.) Bornet

Alg. de Schousb., Mem. Soc. nat. Sci. nat., Cherbourg, 28: 175, 1892; Forti in De Toni, Sylloge Algarum, 5: 61, 1907; Geitler, Kryptogamenflora, 220, 1932.

Thallus expanded, leathery, gelatinous, olive-green to brown, about 1 mm. n diam.; cells without sheath 4.5–5.5 μ broad and 7.5–8.8 μ long, blue-green; heath colorless, distinct or diffluent.

In the environs of Shembaganur, Madurai dist. (Frémy, 1942, 21).

## SPECIES INQUIRENDA

### **Gloeothece distans** Stizb.

in Rabenhorst, Algen, no. 971; Fl. Eur. Alg., 2: 60, 1865; Forti in De Toni, Sylloge Algarum, 5: 61, 1907;

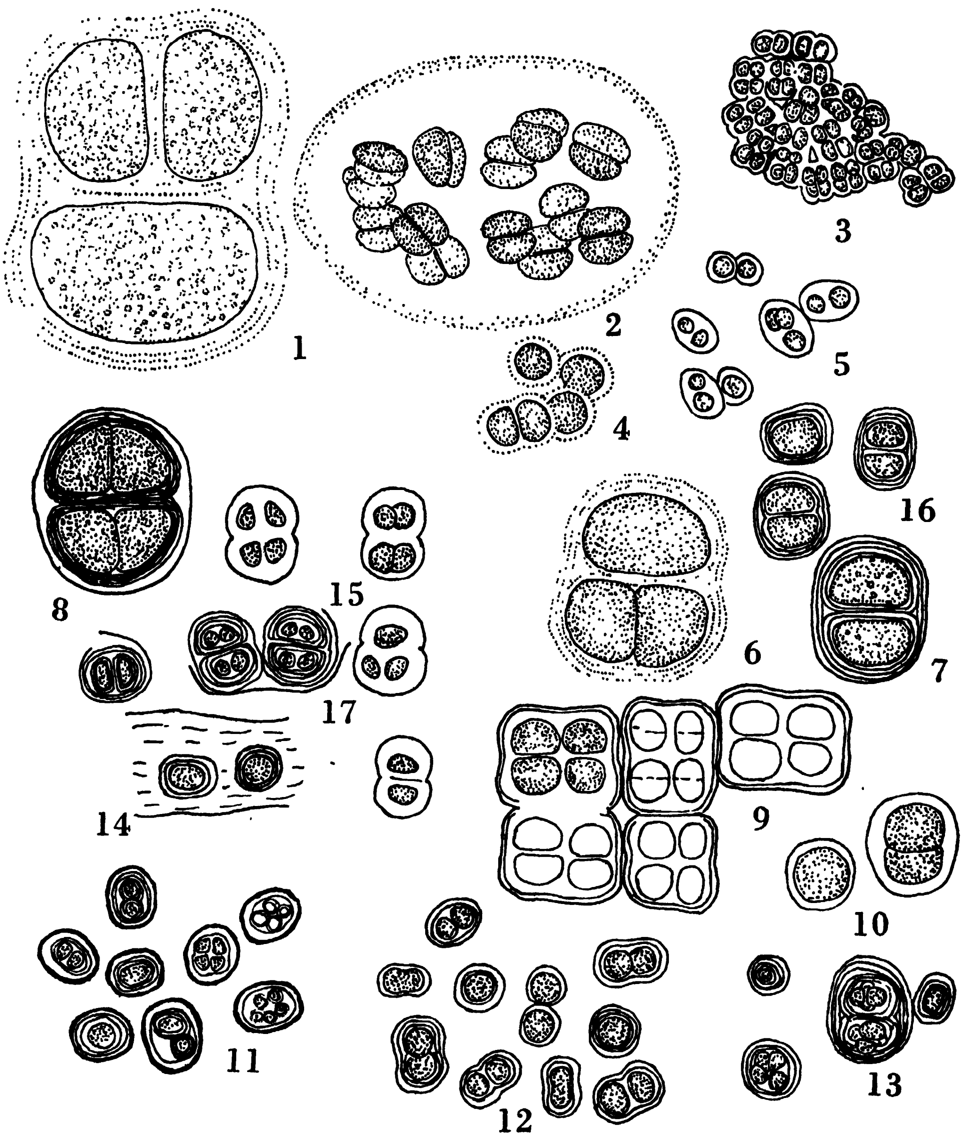

PLATE 26, Figs. 1–17.

1. *Chroococcus giganteus* West, W. (after Smith); 2. *C. limneticus* Lemm. (after Smith); 3 & 9. *C. cohaerens* (Bréb.) Näg. (3 after Wille and 9 after Hollerbach in Elenkin); 4, 15. *C. minutus* (Kütz.) Näg. (4 after Smith, 15 after Wille); 5. *C. pallidus* Näg. (after Wille); 6. *C. turgidus* (Kütz.) Näg. (after Smith); 7, 16. *C. tenax* (Kirchn.) Hieron. (7 after Hollerbach in Elenkin as *Gloeocapsa tenax* and 16 after Wille); 8. *C. turgidus* v. *maximus* Nygaard (after Nygaard); 10. *C. indicus* v. *epiphyticus* Ghose (after Ghose); 11. *C. montanus* v. *hyalinus* Rao, C. B. (after Rao, C. B.); 12. *C. montanus forma* Rao, C. B. (after Rao, C. B.); 13. *C. minimus* v. *crassus*, Rao, C. B. (after Rao, C. B.); 14. *C. turgidus* v. *solitarius* Ghose (after Ghose); 17. *C. schizodermaticus* West, W. (after West).

Thallus diffluent, 6–10 cm broad, lubricous, pale olivaceous; cells oval, 6–10 μ broad, up to 1½ times as long as broad, pale greenish, contents granular; sheath thin, colorless, lamellated; cells single or two together in colonies, colonies oval, 8–25 μ broad.

Slow sand filters, Madras (Ganapati, 1940a, 246).

## APHANOCAPSA Näg.

Gatt. einzell. Algen, 52, 1849.

Cells spherical or nearly so, many loosely arranged without an order, forming a formless gelatinous mass, often a few cm. in diam., mucilage homogeneous, colorless, cells often with a thin more or less gelatinized individual sheaths; division in two (or various?) directions, often two, four and sometimes many within a common mucilaginous envelope of the parent cell; nannocytes present in some species, formed by repeated division.

Type species: *A. parietina* Näg. Geitler (1942) proposes *A. testacea* (A. Br.) Näg., as the lectotype. This is based on the ground that the type species proposed by Nägeli is not definitely identifiable and that it does not probably represent a normal condition.

Drouet and Daily (1956) based on an examination of type material excluded the following species from this genus:—(1) *Aphanocapsa albida* Zeller (floating in a putrescent salt swamp, Akyab, Zeller, 1873a, 169; 1873b, 176; Theobald, 1883, 24) = Bacteria, (2) *Aphanocapsa crassa* Ghose (in a pond mostly adhering to the submerged parts of the aquatic plants, Rangoon, Ghose, 1927b, 239) = *Schizochlamys aurantia* (Ag.) Drouet and Daily, (3) *Aphanocapsa virescens* (Hass.) Rabenh. (Pl. 21, Fig. 6) (in soils, Lahore, Singh, H. D., 1933, 106) = Flagellates, and (4) *Aphanocapsa rivularis* (Carm.) Rabenh. (In a pool, Veliyathura, Travancore, Parukutty, 1940, 117) = *Palmogloea protuberans* (Sm. and Sow.) Kütz. Drouet and Daily, however, have not seen the type material of Ghose. The following species is also eliminated: *Aphanocapsa serpentina* ( ? ) (In ponds, Ferozepur and Shaharanpur dists., Randhawa, 1936a, 405; 1936c, 42).

### KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | In saltwater | 1. *A. littoralis* (p. 131) |
| 1. | In freshwater | 2 |
| 2. | Planktonic species | 3 |
| 2. | Attached or aerophytic | 5 |
| 3. | Cells 5–8 μ diam. | 2. *A. roeseana* (p. 131) |
| 3. | Cells 3.5–4.5 μ diam. | 3. *A. pulchra* (p. 132) |
| 3. | Cells up to 3.2 μ diam. | 4 |
| 4. | Cells 2–3.2 μ diam. | 4. *A. koordersi* (p. 132) |
| 4. | Cells 1.5–2 μ diam. | 5. *A. elachista* (p. 132) |
| 4. | Cells 0.5–0.75 μ diam. | 6. *A. delicatissima* (p. 133) |

5. Cells 4–8 μ diam. .......... 6
5. Cells smaller than 4 μ diam. .......... 7
    6. Cells 5–8 μ diam., colonies large, colored .......... 2. *A. roeseana* (p. 131)
    6. Cells 4–6.2 μ diam., colonies small, colorless ... 7. *A. banaresensis* (p. 133)
    6. Cells 4–7 μ diam. .......... 8. *A. biformis* (p. 134)
7. Cells aerophytic .......... 8
7. Cells submerged .......... 9
    8. Cells 4.5–5.5 μ diam., brownish .......... 9. *A. brunnea* (p. 134)
    8. Cells 3.2–5.6 μ diam. .......... 10. *A. grevillei* (p. 134)
9. In thermal waters .......... 11. *A. thermalis* (p. 135)
9. Not in thermal waters .......... 10
    10. Cells 2.5–4 μ diam., aerophytic .......... 12. *A. montana* (p. 135)
    10. Cells 2–3 μ diam., in the mucilage of other algae and Rotifers 13. *A. muscicola* (p. 135)

### 1. **Aphanocapsa littoralis** Hansgirg

Beitr. zur Kenntnis der Meeresalg. und Bact. Fl., Sitzb. K. Böhm. Ges. Wiss., Math. Nat. Cl., 229, 1892; Forti in De Toni, Sylloge Algarum, 5: 70, 1907; Geitler, Kryptogamenflora, 153, fig. 66b, 1932; Frémy, Cyano. cotes d'Eur., 15, pl. 3, fig. 1, 1933.

Pl. 21, Fig. 1

Thallus amorphous without any definite shape, mucilaginous, blue-green or yellowish; cells spherical to subspherical, 4–6 μ diam., single or in twos, densely or sparsely aggregated.

Planktonic in Indian Ocean (Karsten, 1907, 401); among other algae near Shingle island (Iyengar and Desikachary, 1944, 38), in brackish waters, Veli near Trivandrum (Parukutty, 1940, 117), Cape Comorin (Venkataraman, 1957, 472).

The species is extremely variable.

Parukutty describes the cells as 3.5–5 μ diam. in her collection from Veli.

#### Var. **macrococca** Hansg.

*loc. cit.*, 229, 1892; Geitler, Kryptogamenflora, 153, 1932; Frémy, Cyano. cotes d'Eur., 15, 1933.

Cells 6–10 μ diam.

On soil near seashore, Chowpathy, Bombay (Dixit, 1936, 195).

The cells in the Bombay material are 4.5–10 μ diam.

### 2. **Aphanocapsa roeseana** de Bary

Hedwigia, 9: 74, 1870; Forti in De Toni, Sylloge Algarum, 5: 72, 1907; Geitler, Kryptogamenflora, 157, 1932.

Thallus broad, irregularly spherical, brownish green to blue-green, often gelatinous and up to 30 cm.; cells 5–8 μ diam., nearly oval, pale blue-green, mucilage sheath homogeneous.

In the environs of Shembaganur near Madurai (Frémy, 1942, 21).

### 3. **Aphanocapsa pulchra** (Kütz.) Rabenh.

Fl. Eur. Alg., 2: 49, 1865; Forti in De Toni, Sylloge Algarum, 5: 73, 1907; Frémy, Myxo. d'Afr. équat franc., 22, fig. 22, 1929; Geitler, Kryptogamenflora, 155, fig. 69g, 1932; Frémy, Cyano. cotes d'Eur., 14, pl. 2, fig. 3, 1933.

Pl. 21, Fig. 2

Thallus gelatinous, homogeneous, blue-green, tuberculate, attached or free; cells spherical, 3.5–4.5 (4.8) μ diam., loosely arranged, single or in twos, pale blue-green; individual sheaths of cells indistinct.

Tycholimnetic plankton in tanks and lakes, Anuradhapura, Kalawewa tank and lake Cantelai in Ceylon (Crow, 1923b, 138); in cultures of crude sea salt from Dadar near Bombay (Hof and Frémy, 1932-33, p. 148); Benaras (Rao, C. B., 1937b, 342), Namdur (Rao, C. B., 1938a, 82); on wet soils in low-lying areas, Puri (Rao, C. B., 1938b, 158).

### 4. **Aphanocapsa koordersi** Strom

Algol. notes, Nyt Mag. Naturvid., 61: 128, fig., 1923; Geitler, Kryptogamenflora, 155, fig. 68, 1932.

Pl. 23, Fig. 1

Colony spherical, dull green to blue-green, 2–3 mm. in diam.; cells loosely arranged or in groups of four, spherical, 2.2–2.8 μ in diam.

Planktonic in stagnant waters.—Benaras (Rao, C. B., 1937b, 34) and in River Hooghly (Biswas, 1942, 198).

Rao (*loc. cit.*) records the cells as 2.2–3.2 μ in diam. in his Benaras collection.

### 5. **Aphanocapsa elachista** W. et G. S. West

Algae from West Indies, J. Linn. Soc., Bot., 30: 276, pl. 15, figs. 9–10, 1894; Forti in De Toni, Sylloge Algarum, 5: 73, 1907; Frémy, Myxo. d'Afr. équat. franc., 21, fig. 21, 1929; Geitler, Kryptogamenflora, 156, fig. 69b, 1932.

Pl. 21, Fig. 5

Colony small, spherical or ellipsoidal, 26–38 μ in diam., mucilage thin, colorless, homogeneous, often diffluent; cells very loosely arranged single or in pairs, 1.5–1.8 μ seldom up to 2 μ broad, blue-green.

Tycholimnetic in Andankulam near Trincomalie, Anuradhapura; and tank Basawakulam in Ceylon (Crow, 1923b, 138); Madras (Ganapathi, 1940a, 246) in India; epiphytic in a pond, Rangoon in Burma (Skuja, 1949, 16).

### Var. **conferta** W. et G. S. West

On the Periodicity of phytoplankton in some British Lakes, J. Linn. Soc. Bot., 40: 432, pl. 19, fig. 1, 1932; Frémy, Myxo. d'Afr. équat. franc., 21, fig. 21, 1929; Geitler, Kryptogamenflora, 157, fig. 69, e, f, 1932.

Pl. 22, Fig. 10

Cells 1.6–2 μ diam., colony 52 × 73 μ, cells more closely arranged than in the type.

In a tank at Bandra, Bombay (Gonzalves and Joshi, 1946, 162).

Geitler (1932) suggests its inclusion with the type of the species itself.

### Var. **irregularis** Boye-Petersen

Freshwater Cyanophyceae of Iceland, 265, 1923.

Thallus irregular, not free swimming; closely arranged, 1–2 μ diam.

On the surface of a pond, Rangoon, in Burma (Skuja, 1949, 16).

### 6. **Aphanocapsa delicatissima** W. et G. S. West

On the Periodicity of Phytoplankton in some British Lakes, J. Linn. Soc. Bot., 40: 431, pl. 19, figs. 2, 3, 1912; Geitler, Kryptogamenflora, 157, fig. 69c, d, 1932.

Colony spherical, ellipsoidal or irregular, 14–30 × 15–50 μ, with colorless or yellowish, homogeneous, mucilaginous envelope; cells spherical, 0.5–0.75 μ diam., loosely arranged, grey to pale blue-green.

Plankton, in a small shallow bay near Anuradhapura and in Gregory lake in Ceylon (Crow, 1923b, 139; Holsinger, 1954, 9).

### 7. **Aphanocapsa banaresensis** Bharadwaja

Myxophyceae of the United Provinces, Proc. Indian Acad. Sci., B, 2: 96, fig. 1B, 1935.

Pl. 22, Fig. 8

Plant mass soft, spherical, hollow, irregularly hyaline or cream colored, up to 1.5 cm. in diam., cells oval or almost spherical, 4–6.2 μ in diam.; sheath thick, unstratified, hyaline, closely adpressed to the cells, up to 1 μ thick.

In a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

The species resembles *A. roeseana* de Bary but differs in the color of the thallus and also in the size of the cells.

### 8. **Aphanocapsa biformis** A. Br.

in Rabenhorst, Fl. Eur. Alg., 2: 246, 1865; Forti in De Toni, Sylloge Algarum, 5: 68, 1907; Geitler, Kryptogamenflora, 158, fig. 70, 1932.

Pl. 21, Figs. 3, 4

Thallus olive green, gelatinous, often expanding; cells 4–7 μ diam., spherical, mostly with a special envelope, loosely arranged, 2–4 together in a common mucilaginous envelope; nannocytes about 2 μ diam.

On moist ground and on barks of trees. — Lahore in Pakistan (Ghose, 1924, 336); Rangoon (Ghose, 1927a, 221; 1927e, 80) and in Kamaw in Kisseraing island in Burma (Ghose, 1927c, 245); in a pool in Valiyathura, Travancore in India (Parukutty, 1940, 17).

According to Geitler the original collection is not pure and contains many other Chroococcaceae.

### 9. **Aphanocapsa brunnea** Näg.

Gatt. einzell. Algen, 52, 1849; Forti in De Toni, Sylloge Algarum, 5: 71, 1907.

Thallus membranous and gelatinous, diffused, brown; cells spherical, or oblong prior to division, 4.5–5.5 μ diam., single or in twos without individual envelopes.

In road slimes and epiphytic on tree trunks. — Calcutta (Bruhl & Biswas, 1923, 2; Biswas, 1925, 3) in India and Rangoon in Burma (Skuja, 1949, 16).

Geitler (1932) places this species in *Aphanocapsa grevillei.*

### 10. **Aphanocapsa grevillei** (Hass.) Rabenh.

Fl. Eur. Alg., 2: 50, 1865; Forti in De Toni, Sylloge Algarum, 5: 73, 1907; Frémy, Myxo. d'Afr. équat. franc., 25, fig. 25, 1929; Geitler, Kryptogamenflora, 159, fig. 71, 1932.

Pl. 21, Fig. 9

Thallus gelatinous, spherical or hemispherical, light blue-green; cells spherical, 3.2–5.6 μ diam., contents finely granular, blue-green, closely arranged in a homogeneous mucilage; individual envelopes not distinct.

Planktonic in lakes, tanks, stagnant portions of paddy fields, rivers and on moist ground. — Tank Andankulam near Trincomalie at Anuradhapura, Ceylon (Crow, 1923b, 138); Calcutta (Bruhl and Biswas, 1923, 3; Biswas, 1925, 3; Banerji, 1936, 297; Biswas, 1942, 198), Hyderabad (Ghousuddin, 1936, 149) and Benaras (Rao, C. B., 1937b, 342) in India.

### 11. **Aphanocapsa thermalis** (Kütz.) Brügg.

Bundn. Alg., Jahresber. Natürf. des Graubundens, n.f., 8: 244, 1863; Forti in De Toni, Sylloge Algarum, 5: 74, 1907; Geitler, Kryptogamenflora, 159, 1932.

= *Merismopedia thermalis* Kütz., Phyc. generalis, 163, 1843.

Thallus gelatinous; cells spherical or slightly ellipsoidal, 2.5–4.2 μ broad, closely arranged, blue-green; mucilage homogeneous, distinct sheaths seen around cells at the periphery of the thallus.

Hot springs at Vajreshwari, near Bombay at 40–49°C (Gonzalves, 1947, 24).

Drouet and Daily (1956, 89) place it back into *Merismopedia* ( = *Agmenellum thermale* (Kütz.) Drouet and Daily).

### 12. **Aphanocapsa montana** Cramer

in Wartmann and Schenk, Schweiz. Krypto. no. 134, 1862; Forti in De Toni, Sylloge Algarum, 5; 72, 1907; Geitler, Kryptogamenflora, 159, 1932.

Pl. 20, Fig. 8

Thallus of no definite shape, gelatinous, yellow-green, or blue-green, olive colored, light violet or colorless; cells 2.5–4 μ diam., spherical, light blue-green or yellowish, single or in pairs; mucilage colorless, diffluent.

On submerged objects, on *Pithophora* and on tree trunks in U.P., and Calcutta in Bengal (Hansgirg see De Toni, 1907, 72; Randhawa, 1936a, 402, 405; 1936c, 39, Banerji, 1936, 95).

### 13. **Aphanocapsa muscicola** (Menegh.) Wille

Algologische Notizen XXIX, Nyt Mag. f. Naturv. 56, 39, pl. 2, figs. 19–23, 1918; Geitler, Kryptogamenflora, 160, 1932.

Pl. 21, Fig. 7

Colony microscopic; cells spherical 2–3 μ diam., blue-green, 2–4 together, daughter cells often together in a common mucilage envelope, mucilage thick, colorless, white or greyish blue.

In a pool and epiphytic on *Croton*, Rangoon, in Burma (Skuja, 1949, 16).

## SPECIES INQUIRENDA

**Aphanocapsa crassa** Ghose

Myxophyceae of Rangoon, III, J. Burma Res. Soc., 17: 239, pl. 2, fig. 3, 1927b.

Pl. 22, Fig. 6

Stratum gelatinous, delicate, brownish; cells generally single, globose, not very closely arranged, 7–12 μ thick, brownish green.

Mostly adhering to submerged parts of aquatic plants in a pond, Rangoon (Ghose, *loc. cit.*).

Ghose described the cells as brownish-green ( ? ). Drouet and Daily (1956) eliminated this species as a *Schizochlamys aurantia*.

## APHANOTHECE Näg.

Gatt. einzell. Algen, 59, 1849.

Cells ellipsoidal to cylindrical, straight, or slightly bent, many in a more or less shapeless expanded thallus, mucilage homogeneous, occasionally with lamellated individual envelopes, often gelatinizing; division transverse. Nannocytes present.

Type species: *A. microscopica* Näg.

Movement of the cells in *Aphanothece microscopica* Näg., has been described.

The generic name *Coccochloris* has precedence over *Aphanothece* but has been rejected by Nägeli himself. Drouet and Daily (1956) recognise the genus *Coccochloris* and have made some changes in the species included here in the genus as reported from the region. Daily (The Chroococcaceae of Ohio, Kentucky and Indiana, Amer. Midl. Nat., 27: 636–661, 1942) includes *Aphanothece* in *Aphanocapsa* and prefers the term *Anacystis* Menegh. Smith (1951) adopts *Anacystis* but includes only such *Aphanothece* whose cells have a clear evident individual envelopes.

Drouet and Daily exclude *A. clathrata* W. & G. S. West as a Bacteria (1956, p. 143). They include *A. stagnina, A. bullosa, A. naegellii, A. microscopica* and *A. pallida* under *Coccochloris stagnina* Sprengel, *A. castagnei* under *C. elabens* (Bréb.) Dr. & D., *A. saxicola* in *C. peniocystis* (Kütz.) Dr. & D., *A. nidulans* in *Anacystis marina* (Hansg.) Dr. & D., and *A. caldariorum* and *A. conferta* in *Anacystis montana* (Lightf.) Dr. & D.

### KEY TO THE SPECIES

1. Thallus firm, gelatinous, spherical or hemispherical, 3–6.5 μ diam.
1. *A. stagnina* (p. 137)

1. Thallus mucilaginous, expanded, amorphous .................................... 2
2. Cells up to 2 μ broad .................................... 3
2. Cells broader .................................... 5
3. Cells with gas vacuoles, smaller than 1 μ broad, clathrate ... 2. *A. clathrata* (p. 137)
3. Cells 1 μ broad or broader .................................... 4
4. Cells 1–1.5 μ broad .................................... 3. *A. nidulans* (p. 138)
4. Cells 1.5–2 μ broad .................................... 4. *A. saxicola* (p. 138)
5. Cells up to 3.5 μ broad .................................... 6
5. Cells 3.5–8 μ broad .................................... 7
6. Cells 1.8–3 μ broad, up to 6 times as long as broad, with individual sheaths 5. *A. caldariorum* (p. 138)
6. Cells 2.5–3.5 μ broad, up to 2 times as long as broad, with individual sheaths 6. *A. conferta* (p. 140)
6. Cells 2–3.5 μ broad, up to twice as long as broad, without individual sheaths 7. *A. castagnei* (p. 140)
7. Cells (3-)5–8 μ broad .................................... 8. *A. pallida* (p. 140)
7. Cells 3.5–5 μ broad .................................... 8
8. Subaerial .................................... 9. *A. naegellii* (p. 141)
8. Submerged .................................... 9
9. Thermal .................................... 10. *A. bullosa* (p. 142)
9. Non-thermal .................................... 11. *A. microscopica* (p. 142)

## 1. **Aphanothece stagnina** (Spreng.) A. Br.

in Rabenhorst, Fl. Eur. Alg., 2: 66, 1865; Forti in De Toni, Sylloge Algarum, 5: 76, 1907; Boye-Peterson, Freshwater Cyanophyceae of Iceland, Bot. of Iceland, 2, 1923; Frémy, Myxo. d'Afr. équat. franc., 26, fig. 26, 1929; Geitler, Kryptogamenflora, 164, fig. 72, 75a, b, 1932; Frémy, Cyano. cotes d'Eur. 18, pl. 3, fig. 5, 1933.

Pl. 21, Fig. 10

Thallus gelatinous, spherical, ellipsoidal, up to many cm. in diam., pale blue-green, dull brown or brownish, in the inside often with calcareous crystals; cells oblong, more or less ovoid or cylindrical, 3–6.5 μ broad, 4.5–11 μ long, more or less blue-green, densely or sparsely arranged, generally densely in the peripheral region of the colony and sparsely in the inside of the colony, without individual envelopes, homogeneous mucilage.

Free-floating in lakes, streams and paddy fields.—Ambalagodda in Ceylon (Crow, 1923b, 139); Calcutta (Banerji, 1936, 297); Gorakhpur (Singh, R. N., 1939b, 63); Attingal in Travancore (Parukutty, 1940, 118) and Shembaganur near Madurai (Frémy, 1942, 21); Madras ( ! ) and in stagnant portions of a stream near Renigunta ( ! ).

## 2. **Aphanothece clathrata** W. et G. S. West

Trans. Roy. Irish Acad., 33: 111, pl. 10, figs. 9–10, 1906; Geitler, Kryptogamenflora, 166, fig. 74a, 1932.

Pl. 22, Fig. 2

Thallus microscopic, small, when planktonic, or large when benthic, often irregular, clathrate, with colorless homogeneous mucilage; cells 0.6–0.7 ( – 1) μ broad, (2.5 – ) 3.5–4.5 μ long, cylindrical, straight or slightly curved, densely packed, pale blue-green.

Free-floating in circular patches in a glass jar in the laboratory, Rangoon in Burma (Skuja, 1949, 16).

### 3. **Aphanothece nidulans** Richter, P.

Bot. Notiser, Lund, 128, 1884; Forti in De Toni, Sylloge Algarum, 5: 80, 1907; Geitler, Kryptogamenflora, 168, fig. 75c, 1932.

Pl. 22, Fig. 1

Thallus irregularly expanded, often found between other algae, plankton forms more or less round; cells cylindrical, straight or slightly bent, 1–1.5 μ broad, up to 3.5 μ long, blue-green, most densely arranged; mucilage sheath mostly diffluent, colorless or yellow to brownish yellow.

In slow sand filters, Madras (Ganapathi, 1940a, 246); in Gregory Lake in Ceylon (Holsinger, 1954, 9).

### 4. **Aphanothece saxicola** Näg.

Gatt. einzell. Algen, 60, 1849; Forti in De Toni, Sylloge Algarum, 5: 81, 1907; Frémy, Myxo. d'Afr. équat. franc., 28, fig. 28, 1929; Geitler, Kryptogamenflora, 169, 1932.

Pl. 22, Fig. 11

Thallus mucilaginous, colorless or yellowish; cells cylindrical, 1–2 μ broad and 2–3 times as long, single or in pairs, seldom many in a common, mucilaginous envelope, pale blue-green.

Planktonic in paddy fields, or in drains, or in soil algal cultures. — Benaras (Rao, C. B., 1936, 165), in the environs of Shembaganur near Madurai (Frémy, 1942, 21) and Allahabad (Mitra, 1951, 360).

Rao, C. B. (*loc. cit.*) describes a form from Benaras.

### 5. **Aphanothece caldariorum** Richter, P.

Hedwigia, 20: 192, 1880; Forti in De Toni, Sylloge Algarum, 5: 79, 1907; Geitler, Kryptogamenflora, 169, fig. 79, 1932.

Thallus slimy, often expanded, blue-green, greyish green or light violet; cells cylindrical, bow-shaped or sigmoid, sometimes, straight, 1.8–3 μ broad, up to 12 μ long, mostly with a distinct often lamellated, colorless, individual

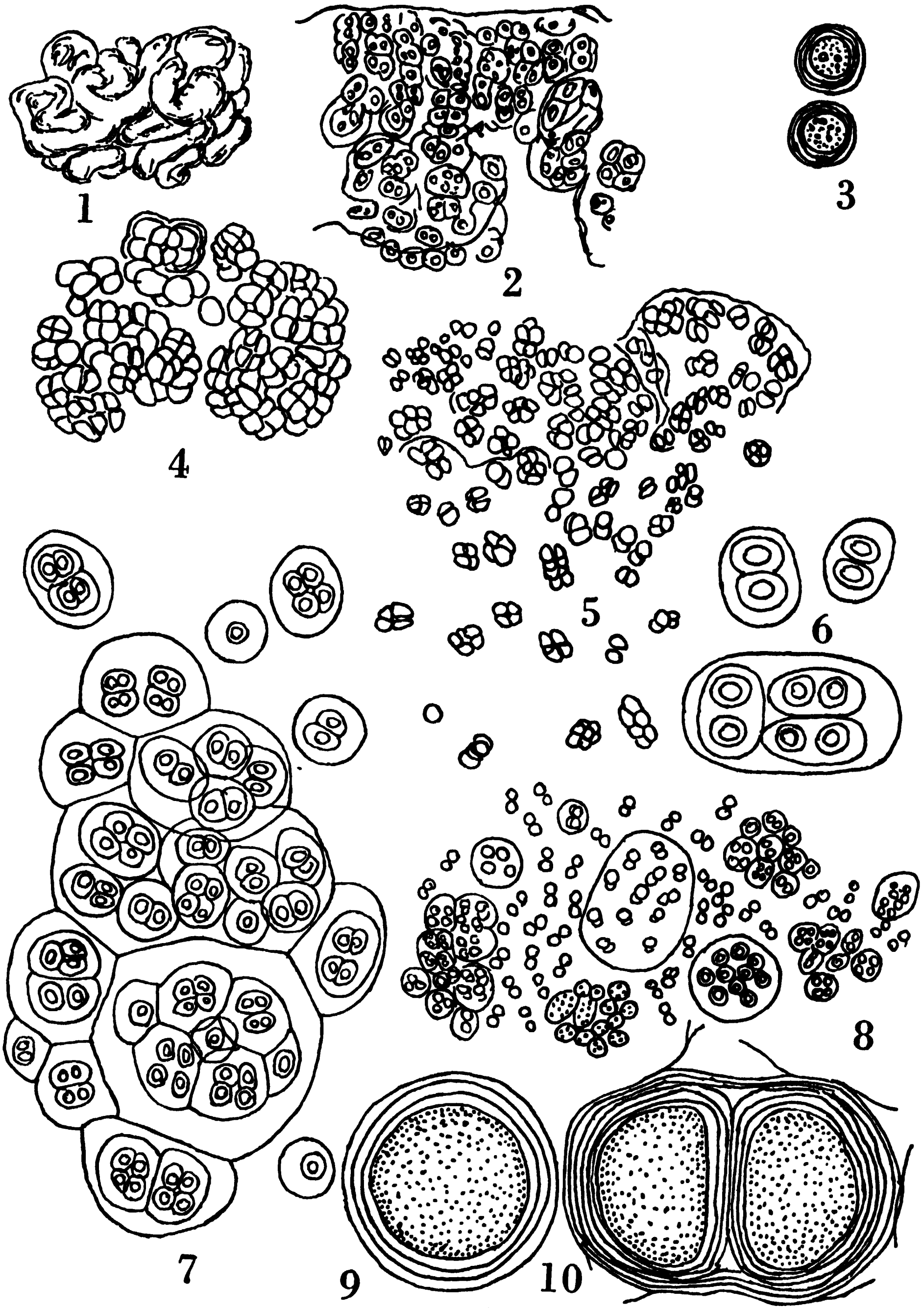

PLATE 27, Figs. 1–10.

1, 2. *Placoma vesiculosa* Schousb. (after Bornet & Thuret); 3, 9, 10. *Chroococcus macrococcus* (Kütz.) Rabenh. (3 after Kützing, 9, 10 after Frémy); 4, 5. *Gloeocapsa crepidinum* Thuret (after Bornet and Thuret); 6. *G. gelatinosa* Kütz. (after Frémy); 7. *G. sanguinea* (Ag.) Kütz. (after Cooke); 8. *G. livida* (Carm.) Kütz. (after Menegh.).

membranes, at the ends of cells generally one ectoplast present, cells blue-green; nannocytes through division of cells in three directions, often the entire thallus in a state of nannocyte formation.

On the barks of *Hevea brasiliensis*, Kamaw, Burma (Ghose, 1927d, 252).

Hollerbach (in Elenkin, 1938, p. 255) places this under the genus *Gloeothece* (*G. caldariorum* (P. Richter) Hollerb. cf. however, Elenkin, 1938, p. 152). He includes under this combination, *Gloeothece inconspicua* A. Br., *Aphanocapsa nebulosa* A. Br., and *Aphanothece muralis* (Tomasch.) Lemm. Elenkin earlier in the same volume places the same species again under *Aphanothece conferta* with a query.

### 6. **Aphanothece conferta** Richter

in Hauck and Richter, Phyk. Univ., 10: 487, 1892; Forti in De Toni, Sylloge Algarum, 5: 84, 1907.

Thallus gelatinous, membranous, expanded, dirty green, or olive brown; cells single or in twos, oblong, or spherical, 2.5–3 μ diam., 1½–2 times as long as broad; sheath diffluent, colorless; contents pale blue-green, granular.

In cultures of paddy field soil from Thana and Goregaon near Bombay (Gonzalves and Gangla, 1949, 53).

### 7. **Aphanothece castagnei** (Bréb.) Rabenh.

Fl. Eur. Alg., 2: 64, 1865; Forti in De Toni, Sylloge Algarum, 5: 81, 1907; Geitler, Kryptogamenflora, 171, 1932; Frémy, Cyano. cotes d'Eur., 19, pl. 3, fig. 8, 1934.

Pl. 21, Fig. 8

Thallus gelatinous, without any definite shape, slimy, blue-green or brown; cells ellipsoidal to cylindrical, 2–3.6 μ broad, 4–8 μ long, mostly densely arranged, blue-green; sheath diffluent, colorless or yellowish.

Free-floating or forming a scum on surface of ponds and pools or drains, also epiphytic. — Maymyo islands (Ghose, 1927d, 252), on *Magnifera indica*, and in drains, Rangoon (Skuja, 1949, 16), in Burma; Shembaganur near Madurai (Frémy, 1942, 21), Borivli near Bombay (Gonzalves and Joshi, 1943a, 37), Singaperumal koil ( ! ), Vandalur ( ! ), and Kodaikanal ( ! ).

The specimens from Madras State had cells 2–3.9 (–5) μ broad and 3.9–7.9 μ long.

### 8. **Aphanothece pallida** (Kütz. ) Rabenh.

Fl. Eur. Alg., 2: 64, 1865; Krypto. — Fl. Sachsen, 1: 76, 1863; Forti in De Toni, Sylloge Algarum, 5: 83, 1907; Frémy, Myxo. d'Afr. équat. franc., 29, fig. 31, 1929; Geitler, Kryptogamenflora, 171, fig. 78, 1932; Frémy, Cyanophycées cotes d'Eur., 19, pl. 3, fig. 7, 1933.

= *Microcystis pallida* Lemm., Kryptogamenflora der Mark Brandenburg, 3: 77, 1907.

Pl. 22, Fig. 3

Thallus gelatinous, soft, blue-green or brownish, up to 4–6 mm diam.; cells oblong, elliptical, or cylindrical, 3–8 μ broad and 1½–3 times as long as broad, blue-green, olive green; sheath very distinct in the peripheral part of the thallus, often lamellated, yellow to brown, diffluent in the inner part.

On moist situations and free-floating in ponds and pools and in paddy fields. — Matheran (Schmidle, 1900b, 162), Bandra (Gonzalves and Joshi, 1946, 175), near Bombay; Benaras (Rao, C. B., 1936, 165); Panihati in Bengal (Banerji, 1936a, 297); Narsapur, Ellore, Coconada, Polamur, Namdur in Andhra (Rao, C. B., 1938a, 82); Puri, Berhampur and Cuttack in Orissa (Rao, C. B., 1938b, 158); Dharbanga in Bihar (Rao, C. S., 1939, 143); and Vandalur near Madras ( ! ); Lahore in Pakistan (Ghose, 1924, 336).

According to Geitler (1932, 172), the species has great resemblances to *Gloeothece*.

The cells in the Indian forms are 5–7 (–8) μ (with envelope 10–20 μ br.,) and (5.2–) 6–12 (–23) μ long (with envelope 10–30 μ).

### f. **minor** Dixit

Myxophyceae of Bombay Presidency-I, Proc. Indian Acad. Sci., B, 2: 95, 1936.

Diam. colony up to 1.8 cm.; cells 2.5–4 μ broad, up to 6.5 μ long; cells with envelope 5.5–9 μ broad and 7.5–12 μ long.

On the bed of stagnant rivulet, Santa Cruz and Kurla, near Bombay. (Dixit, *loc. cit.*).

The form is characterised by the smaller cells. Dixit's form resembles very much v. *macrococca* Brügg. (Alg. exs. 1093, 1863) which has been transferred to *A. castagnei*. The identity of Dixit's form is doubtful.

### 9. **Aphanothece naegelii** Wartm.

In Rabenhorst, Fl. Eur. Alg., 2: 65, 1865; Forti in De Toni, Sylloge Algarum, 5: 77, 1907; Lemmermann, Kryptogamenflora der Mark Brandenburg, 3: 70, 1910; Geitler, Kryptogamenflora, 172, 1932.

Pl. 22, Fig. 7

Thallus gelatinous, yellow-brown or olive green; cells oval, after division spherical, 3.5–4.5 × 6.5–8 μ in size, blue-green; sheath diffluent.

On moist soil or soil cultures, Benaras (Rao, C. B., 1936, 165) in India; Lahore in Pakistan (Singh, H. D., 1933, 106) and Kyauktan and near it in Burma (Skuja, 1949, 16).

### 10. **Aphanothece bullosa** (Menegh.) Rabenh.

Fl. Eur. Alg., 2: 65, 1865; Forti in De Toni, Sylloge Algarum, 5; 84, 1907; Frémy, Myxo. d'Afr. équat. franc., 30, fig. 33, 1929; Geitler, Kryptogamenflora, 172, 1932.

Pl. 22, Fig. 12

Thallus more or less spherical, irregularly lobed, up to 15 cm. diam., greenish to yellow, soft; cells long cylindrical, 3.5–5 μ broad, 1½–2½ times as long, with or without individual envelopes, blue-green or olive green.

Free-floating.—Benaras (Rao, C. B., 1937b, 343); Berhampur (Rao, C. B., 1938b, 158); Namdur (Rao, C. B., 1938a, 82); cultures from garden soil, Allahabad (Mitra, 1951, 360); attached to aquatic plants, Khajiar (Gupta, 1950, p. 110).

According to Rao the cells are 3.8–5.4 μ broad and 6–13.2 μ long forming a deep blue-green stratum.

### 11. **Aphanothece microscopica** Näg.

Gatt. einzell. Algen, 59, pl. 1, H, 1849; Forti in De Toni, Sylloge Algarum, 5: 83, 1907; Frémy, Myxo. d'Afr. équat. franc., 28, fig. 30, 1929; Geitler, Kryptogamenflora, 172, fig. 79, 1932.

Pl. 22, Figs. 4, 5, 9

Thallus small, gelatinous, at first rounded later amorphous, up to 2 mm diam.; cells oblong cylindrical, more or less 4.5 μ broad, 1½–2 times as long as broad, with sometimes distinct, individual sheath, blue-green, colorless nannocytes present.

Free-floating. — Mahim, near Bombay (Schmidle, 1900b, 162); Benaras (Rao, C. B., 1936, 165); Berhampur (Rao, C. B., 1938b, 159), in the environs of Shembaganur, Madurai dist. (Frémy, 1942, 21); and on submerged soil at the end of a pond, Ellore (Rao, C. B., 1938a, 82).

According to Rao, the cells are 4–5 μ broad and 6–9.5 μ long.

Canabaeus (Forsch. Bayer. Bot. Ges., Erforsch. Heim. Fl., 2, 1929) has described nannocyte formation in this species. According to her the nannocytes are up to 0.5 μ diam., and formed in cells of 7.2 μ broad after repeated division.

## SYNECHOCOCCUS Näg.

Gatt. einzell. Algen, 56, 1848.

Cells oblong, cylindrical or ellipsoidal, erect, seldom slightly bent with rounded apices, single or in colonies of 2, rarely in fours, mucilage envelope absent or a very thin and narrow one present; division transverse.

Type species: *S. elongatus* Näg.

Perfiljiev, B. V. (Sur la locomotion de l'algue blue *Synechococcus*, J. Microbiol., 2: 286, 1915; also Skuja, Acta Horti Bot. Univ. Latv., 1926;1939; Elenkin, Not. Syst. Inst. Horti Bot. Petropol., 2: 49, 1923; see also Geitler, 1936, p. 42; 1942) reports some kind of active movement of the cells. The movement seems to be brought about by a sort of swelling of the mucilage secreted.

Drouet and Daily (1956, 13) include this genus in *Coccochloris* Sprengel.

### KEY TO THE SPECIES

1. Cells less than 5 μ broad .................................................... 2
1. Cells broader........................................ 1. *S. aeruginosus* (p. 143)
    2. Cells 1.4–2 μ broad, cylindrical ................ 2. *S. elongatus* (p. 143)
    2. Cells 3–4.3 μ broad, ellipsoidal ................ 3. *S. cedrorum* (p. 144)

### 1. **Synechococcus aeruginosus** Näg.

Gatt. einzell. Algen, 56, pl. 1, E, fig. 1, 1849; Forti in De Toni, Sylloge Algarum, 5: 27, 1907; Geitler, Kryptogamenflora, 274, fig. 133d, e, 1932.

=*Synechococcus fuscus* Zeller, Hedwigia, 12: 109, 1873.

Pl. 25, Figs. 6, 12

Cells cylindrical, 5–16 μ broad, up to 30 μ long, single, or 2-4 together, pale blue-green.

On moist soil in stream, Thyttonk and Hpet-wan-Choung, Burma (Zeller, 1873a, 169; Theobald, 1883, 24).

### 2. **Synechococcus elongatus** Näg.

Gatt. einzell. Algen, 56, pl. 1, E, fig. 3, 1849; Forti in De Toni, Sylloge Algarum, 5: 28, 1907; Geitler, Kryptogamenflora, 273, fig. 133a–c, 1932.

Pl. 25, Figs. 7, 8

Cells cylindrical, 1.4–2 μ broad, 1½–3 times as long as broad, single or 2-4 cells together; contents homogeneous and light blue-green.

On submerged rocks in a lake, Vellayani, Travancore (Parukutty, 1940, 118).

The Travancore alga differs from the type (cells 2.5–3.3 μ broad, 3.3–6.6 μ long).

### 3. **Synechococcus cedrorum** Sauvageau

Bull. Soc. Bot. France, 39: 115, pl. 6, fig. 1, 1892; Forti in De Toni, Sylloge Algarum, 5: 26, 1907; Geitler, Kryptogamenflora, 273, 1932.

Cells single or two together, elongate, ellipsoidal (sometimes cylindrical), and finely rounded, 3–4 μ broad, 1¼–2 times as long as broad, 5–10 μ long, contents blue-green.

In cultures of red soil, Vandalur, Madras (Mitra, 1951, 360).

## **SYNECHOCYSTIS** Sauvageau

Algues recolt. en Algerie, Bull. Soc. Bot. France, 39: 115, 1892.

Cells spherical, single or two together after division, or rarely in colonies of a few cells, without distinguishable mucilage envelopes.

Type species: *S. aquatilis* Sauv.

*Synechocystis salina* Wislouch has been observed to show active movements (Wislouch, Acta Soc. Bot. Pol., 2: 99, 1924; also see Geitler, 1942, p. 41). Lund (Naturalist, London, 835: 143–148, 1950) observed similar movements in *Synechococcus aeruginosus*. The latter author correlates movements with bottom flora.

### KEY TO THE SPECIES

| | |
|---|---|
| 1. Cells 5–6 μ diam. .................................... | 1. *S. aquatilis* (p. 144) |
| 1. Cells 2.5–3.5 μ diam. .................................... | 2. *S. pevalekii* (p. 145) |

### 1. **Synechocystis aquatilis** Sauv.

Bull. Soc. bot. France, 39: 121, pl. 6, fig. 2, 1892; Forti in De Toni, Sylloge Algarum, 5: 26, 1907; Geitler, Kryptogamenflora, 270, 1932.

Pl. 25, Fig. 9

Cells spherical, single or in twos, 5–6 μ broad, pale blue-green.

Planktonic in stagnant waters, Benaras (Rao, C. B., 1937b, 346) and Delhi (Rao, C. S., 1940, 126).

The Benaras form is 5.6–6.5 μ diam., and the Delhi form is 4–6.5 μ in diam.

### 2. **Synechocystis pevalekii** Ercegovic

La Vegetation des lithophytes sur les calcaires et les dolomites en Croatie, Acta Bot. Inst. Bot. Univ. R. Zagreb, 1 : 77, pl. 1, fig. 8, 1925; Geitler, Kryptogamenflora, 269, fig. 133f, 1932.

Pl. 25, Fig. 11

Thallus indefinite, among other algae; cells spherical, after division hemispherical, 2.5–3.5 μ broad, single or two together, contents blue-green homogeneous.

Beira lake, Nuwarawewa tank, and Gregory lake, Ceylon (Holsinger, 1954, 10); on bricks with a thin film of water, Madras ( ! ).

The Madras alga was 2–3.5 μ broad.

## **RHABDODERMA** Schmidle et Lautb.

in Schmidle, Beitr. Kenntn. Planktonalg., Ber. dtsch. bot. Ges., 18: 149, 1900.

Cells single or after division two to many in rows or in irregular colonies, long ellipsoidal to cylindrical with rounded ends, straight, lunate or sigmoid, mostly in a homogeneous colorless mucilage, colony membranaceous, flat or roundish; division transverse.

Type species: *R. lineare* Schmidle et Lautb.

The distinctness of the genus from *Gloeothece* and other genera is doubtful. But the retention of the genus is highly practicable.

Single species known from the region.

### **Rhabdoderma gorskii** Wolosz.

Bull. Acad. Cracovie, 35: 127, pl. 14, figs. 34–35, 1917; Geitler, Kryptogamenflora, 277, fig. 135c, 1932.

Pl. 25, Fig. 10

Cells, long cylindrical, slightly bent, 1.5–2 μ broad, 10–13 μ long, blue-green, not in distinct rows.

Planktonic in a rainwater pool, Benaras, India (Rao, C. B., 1936, 167).

Elenkin (Monogr. Algar. Cyano., pars spec., 1: 42, 1938) includes this species under *R. lineare* Schmidle et Lautb. em. Hollerbach. Teiling (Sv. Bot. Tidskrift, 51: 217, 1957) includes this under *Dactylococcposis ellipsoideus.*

## COELOSPHAERIUM Näg.

Gatt. einzell. Algen, 54, 1849.

Cells spherical or hemispherical forming a hollow spherical or somewhat irregular free swimming colonies with or without individual envelopes around cells; colonial mucilage homogeneous or heterogeneous, colorless; colonies dividing by breaking through in the middle.

Type species:-*C. kuetzingianum* Näg.

The distinction between *Gomphosphaeria* and *Coelosphaerium* is not very clear (*see* Geitler, 1932, p. 242). Besides the shape and the planes of cell-division, stress is laid on the nature of the interior of the colonial mucilage. Elenkin (Acta Inst. Bot. Acad. Sci., URSS, ser. 2, fasc. 1, 28, 1933; also Woronichin, Biol. et Morph. du *C. naegelianum* Ung., Arch. Russ. Protistol., 6 (1/4): 155–163, 1927; Elenkin and Hollerbach, Not. Syst. Inst. Crypt. Horti Bot. Petropol., 2 (10): 145–155, 156, 1923) has described a third genus *Woronichinia* with a single species, *W. naegeliana* (Unger) Elenk. ( = *Coelosphaerium naegelianum* Unger). *Woronichinia* resembles very closely *Gomphosphaeria* (*see* also Lemmermann, 1910, 80) but differs from it besides the cell shape in the nature of the mucilage stalk. Both *Gomphosphaeria* and *Woronichinia* differ from *Coelosphaerium* in having a heterogeneous mucilage with distinct radial stalks, while in the last one the mucilage is described as homogeneous. *Coelosphaerium kuetzingianum* (the type species) has stalks similar to *Gomphosphaeria* (*see* Troitkaja; De affin. *Coelosphaerium* et *Gomphosphaeria,* Not. Syst. Inst. Crypt. Horti Bot. Petropol., 2(5): 69–73, 1923). In *Coelosphaerium roseum* Snow ( = *Gomphosphaeria rosea* (Snow) Lemm., Kryptogamenflora der Mark Brandenburg, 3: 80, 1910) the interior of the mucilaginous colony is similar to that in *Gomphosphaeria* colonies. This species is, however, considered identical with *Coelosphaerium kuetzingianum* (*see* Geitler, 1932, 253). Elenkin (Monogr. Algar. Cyano. pars spec., 1: 278, 1938) transfers these two species along with *Gomphosphaeria lacustris* to a new genus *Snowella. Coelosphaerium pallidum* Lemm., has been transferred to the genus *Lemmermannia* Elenk. ( = *Lemmermanniella* Geitler). Drouet and Daily (1956 p. 148) however reject *Lemmermanniella* as based on Bacteria and include the rest of the genera under one genus, *Gomphosphaeria.* The structure of the colonies in the other species of *Coelosphaerium* is not known. There is need for a detailed investigation. Then only the validity of these five genera can be decided. The two genera, *Coelosphaerium* and *Gomphosphaeria* can be easily distinguished by the cell shape and may be retained as distinct even if the internal structure of the colonies of the two genera prove to be somewhat similar (*see* Frémy, 1929, p. 32; Geitler, 1932; also cf. Geitler, 1942).

Lund, J. W. G. (Naturalist, London, 1950, 143) has observed the movements of cells in *Coelosphaerium* spp., but has failed to observe the same in *C. naegelianum.*

## KEY TO THE SPECIES

| | |
|---|---|
| 1. Cells distinctly (2–3 times) longer than broad, with gas vacuoles | 1. *C. naegelianum* (p. 147) |
| 1. Cells spherical | 2 |
| 2. Cells without gas vacuoles | 3 |
| 2. Cells with gas vacuoles | 2. *C. dubium* (p. 147) |
| 3. Cells 1.5–2.5 μ broad, closely arranged | 3. *C. confertum* (p. 148) |
| 3. Cells 2.2–5 μ broad, colony with a thin colonial envelope | 4. *C. kuetzingianum* (p. 148) |

### 1. **Coelosphaerium naegelianum** Unger

Beitr. Kenntnis nied. Alg. Form, Denkschr. Akad. Wiss. Wien, 7: 195, 1854; Geitler, Kryptogamenflora, 249, fig. 122, b, c, 1932.

= *Woronichinia naegeliana* (Unger) Elenkin, Über neue Famil. Cyano. Acta Instit. Bot. Acad. Scient. URSS, ser. 2, fasc. 1, 30-33, 1933.

= *Coelosphaerium kuetzingianum* Näg., Forti in De Toni, Sylloge Algarum, 5: 100, 1907 (ex p.).

= *Gomphosphaeria naegeliana* (Unger) Lemmermann, Kryptogamenflora der Mark Brandenburg, 80, fig. 19 on p. 44, 1910.

Pl. 28, Figs. 9, 16

Colony spherical or ellipsoidal, reniform or irregularly shaped; 50–180 μ diam., with broad radial mucilage stalks; cells oval or ellipsoidal, closely arranged, with gas vacuoles, 3.5–5 μ broad, 5–7 μ long, often with indistinct individual mucilaginous envelopes.

In rain water puddle in Jogeshwari caves, Bombay (Gonzalves and Joshi, 1943b, 121).

### 2. **Coelosphaerium dubium** Grunow

in Rabenhorst, Fl. Eur. Alg., 2: 55, 1865; Forti in De Toni, Sylloge Algarum, 5: 102, 1907; Frémy, Myxo. d'Afr. équat. franc., 32, fig. 37, 1929; Geitler, Kryptogamenflora, 254, fig. 121 f and 122 a, 1932; Frémy, Cyano. cotes d'Eur., 20, pl. 3, fig. 9, 1933.

Pl. 28, Figs. 10, 11, 14, 15

Colony spherical, up to 150 μ broad or irregular with 3–4 colonies placed together, up to 300 μ diam., colonial mucilage firm, not lamellate up to 8 μ thick; cells spherical, closely arranged, 5–7 μ broad, gas vacuoles present.

Planktonic in tanks and lakes at Candy, Anuradhapura, Dambulla and Haberane (Crow, 1923a, 67; 1923b, 140) in Ceylon.

Drouet and Daily (1956, p. 36) include this species under *Anacystis cyanea* (Kütz.) Drouet and Daily.

### 3. **Coelosphaerium confertum** W. et G. S. West

Journ. Bot., Lond., 34: 382, pl. 361, fig. 3, 1896; Forti in De Toni, Sylloge Algarum, 5: 101, 1907; Frémy, Myxo. d'Afr. équat. franc., 31, fig. 34, 1929; Geitler, Kryptogamenflora, 252, 1932.

Colony spherical up to 125 μ diam., with thin colonial mucilage envelope; cells spherical, placed in groups of four, closely arranged, 1.5–2.5 μ broad, light blue-green.

Planktonic in lake at Colombo (Lemmermann, 1907, 267) and at Cantelai, Ceylon (Crow, 1923b, 140).

### 4. **Coelosphaerium kuetzingianum** Näg.

Gatt. einzell. Algen, 54, pl. 1c, 1849; Forti in De Toni, Sylloge Algarum, 5: 100, 1907; Geitler, Kryptogamenflora, 253, fig. 121, c, d, 1932; Frémy, Cyano. cotes d'Eur., 31, fig. 35, 1933.

Pl. 28, Figs. 7, 8

Colony more or less spherical with a thin colonial mucilage envelope, 20–90 μ broad; cells spherical or subspherical, 2.25–5 μ broad, cells closely or loosely arranged.

Planktonic and with other algae, Madras and Kancheepuram ( ! ).

## GOMPHOSPHAERIA Kütz.

Alg. Dec., 16: 151, 1836.

Cells ellipsoidal or cordate, rarely subglobose, seldom very spherical, often in groups of four but also in 2–8, with or without individual envelopes, arranged in a hollow spherical mucilaginous free swimming colony, attached to radially arranged, branched mucilaginous stalks; cell division in two directions at right angles to each other, division of colony into two is also known.

Type species: *G. aponina* Kütz.

The structure of the colony reminds of a similar construction in *Dictyosphaerium.*

Lund failed to observe any movement in the two species of *Gomphosphaeria*, *G. aponina* and *G. lacustris* which he studied.

### KEY TO THE SPECIES

| | |
|---|---|
| Cells 1.5–2.5 μ broad ........................................ | 1. *G. lacustris* (p. 150) |
| Cells (2–) 4–13 μ broad ........................................ | 2. *G. aponina* (p. 150) |

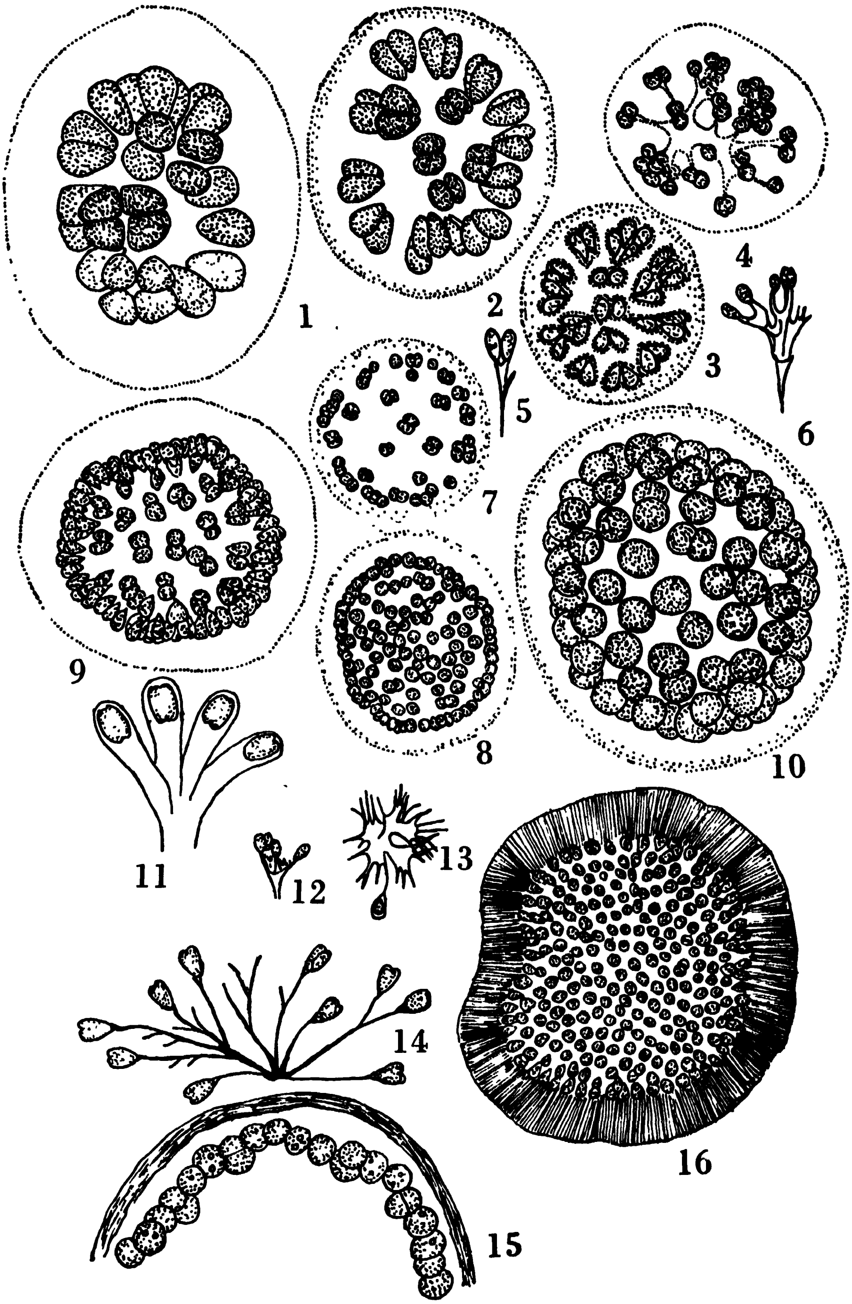

PLATE 28, Figs. 1-16.

1–3. *Gomphosphaeria aponina* Kütz. (1, 2, after Smith and 3 after West); 4–6, 12, 13. *G. lacustris* Chodat; 5, 6, 12, 13. Showing the mucilaginous stalks (4 after Smith, the rest after Chodat); 7, 8. *Coelosphaerium kuetzingianum* Näg. (after West); 9, 16. *C. naegelianum* Unger (9 after Smith and 16 after Elenkin); 10, 11, 14, 15. *C. dubium* Grun. (10 after Smith, 15 after Frémy and 11, 14, after Woronichin).

### 1. **Gomphosphaeria lacustris** Chodat

Etud. biol. lac., Bull. l'Herbier Boisser, 6: 180, fig. 1, 1898; Forti in De Toni, Sylloge Algarum, 5: 99,1907; Frémy, Myxo. d'Afr. équat.·franc., 34, fig. 38, 1929; Geitler, Kryptogamenflora, 243, figs. 117d, e, 118a, 1932; Frémy, Cyano. cotes d'Eur., 21, pl. 4, fig. 1, 1933.

Pl. 28. Figs. 4–6, 12, 13

Colonies spherical or ellipsoidal, often constricted, up to 30 (–40) μ diam., with hyaline mucilage; cells ellipsoidal, spherical or ovoid, 1.5–2.5 μ broad, 2–4 μ long, with distinct or gelatinised individual envelopes, loosely arranged, light blue-green or reddish, mucilaginous stalks of cells narrow or thin, irregular proceeding from the centre of the colony.

Epiphytic, Mandalay and planktonic in a pond, Mandalay and Rangoon, in Burma (Skuja, 1949, 20).

Chodat and Nygaard (Mem. Acad. R. Sc., Denmark, ser. 1, 9: pl. 4, fig. 23, 1929) have well illustrated the structure of the mucilage stalks in this species.

### 2. **Gomphosphaeria aponina** Kütz.

Alg. exsicc. Dec., 16; n. 151, 1836; Tab. phycologicae, 1: 22, pl. 31, fig. 3, 1846; Species Algarum, 233, 1849; Forti in De Toni, Sylloge Algarum, 5: 97, 1907; Frémy, Myxo. d'Afr. équat. franc., 34, fig. 39, 1929; Geitler, Kryptogamenflora, 245, figs. 117a–c, 118b, 1932; Frémy, Cyano. cotes d'Eur., 22, pl. 4, fig. 2, 1933.

Pl. 28, Figs. 1–3

Cells pyriform or cuneate, cordate at longitudinal cell division, 4–14 μ broad and 8–20 μ long, blue-green to olive-green or yellowish mostly with a distinct mucilaginous envelope, placed at the ends of regularly dichotomously or trichotomously branched radial mucilaginous stalks; colonies large 50–90 μ diam., in some up to 125 μ diam.

Sticking to Ammania, Afghanistan (Schaarschmidt, 1886, 241); on mud in India (Hansgirg, *see* Forti in De Toni, 5: 98, 1907); in slow sand filters, Madras (Ganapathi, 1940a, 246); planktonic in beach pools, Madras and Ennore ( ! ).

Biswas (1924, 361) described a new variety, *G. aponina* var. *muralis*.

## **MERISMOPEDIA** Meyen

N. Syst. d. Pflanzen-Physiologie, 3: 440, 1839; in Wiegmann, Arch. f. Naturgesch., 2: 67, 1839.

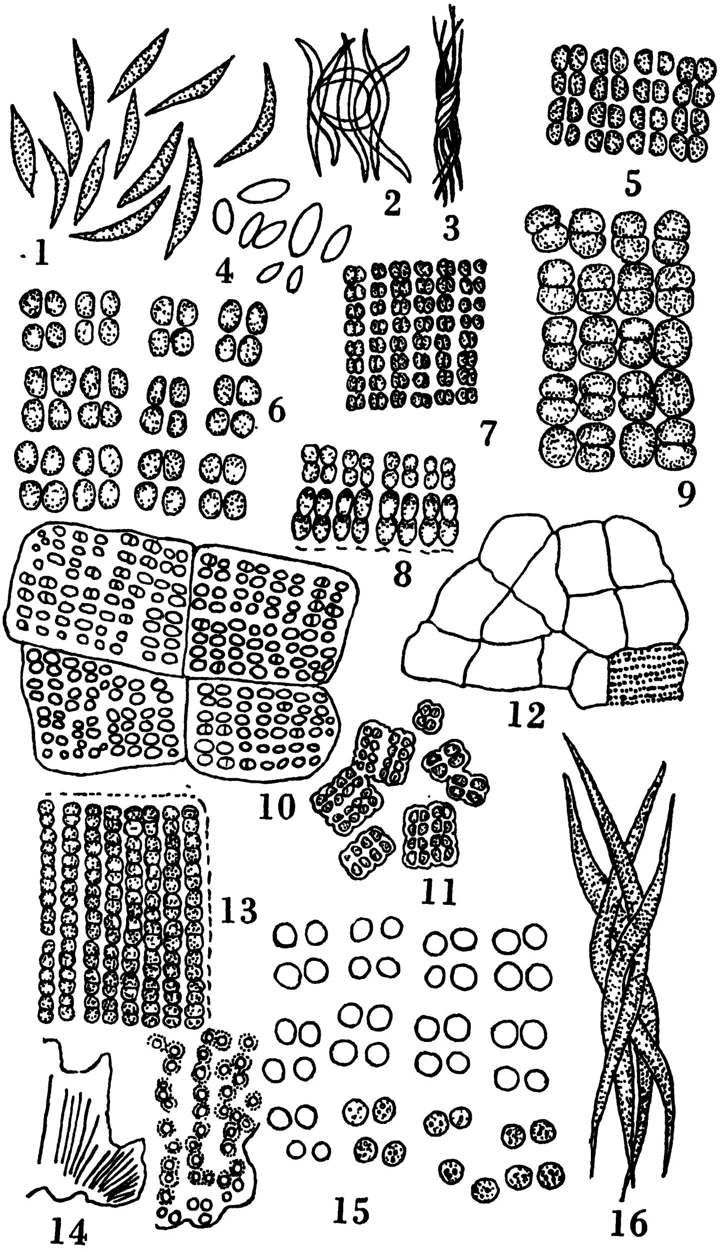

PLATE 29, Figs. 1–16.

1, 2. *Dactylococcopsis raphidioides* Hansg. (1 after Frémy, 2 after Hansgirg); 3. *D. fascicularis* Lemm. (3 after Lemmermann); 16. *D. fascicularis* forma (orig.); 4. *D. pectinatellophila* West, W. (after West); 5. *Merismopedia glauca* (Ehrenb.) Näg. (after Smith); 10. *M. glauca* forma (5 and 10 after Rao, C. S.); 6. *M. punctata* Meyen. (after Smith); 7. *M. tenuissima* Lemm. (after Smith); 8, 12, 13. *M. convoluta* Bréb. (after Ryppow from Elenk,); 9. *M. elegans* A. Br. (after Smith); 11. *M. minima* Beck (after Skuja); 14. *Entophysalis granulosa* Kütz. (after Iyengar and Desikachary); 15. *Merismopedia marssonii* Lemm. (orig.).

Cells 4–16 (or more) in tabular colonies arranged in a homogeneous mucilage, generally in fours, arranged in a single plane, free floating, cells globose, oblong before cell division, subspherical after division; contents blue-green rarely violaceous or reddish; multiplication by division in two directions perpendicular to the plane of the colony.

Type species: *M. punctata* Meyen.

*Pseudoholopedium* (Ryppowa) Elenkin (Actis Instit. Botan. Acad. Scient. URSS., ser. 2, fasc. 1, p. 18) is a monotypic genus with *P. convoluta* (Bréb.) Elenk. ( = *Merismopedia convoluta* Bréb.). This genus is not very distinct from *Merismopedia.*

Lund, J. W. G., (Naturalist, London, 835: 143–148, 1950) observed active movements of cells in *Merismopedia elegans* and *M. glauca.* Niklitshek, (Niklitshek, A. Das Problem der Oscillatorien-Bewegung, 1, Beih. Bot. Centralbl., A, 52: 212, 1934) observed the same in *Merismopedia punctata.*

Eight species have been recorded from the region.

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Thallus convolute | 1. *M. convoluta* (p. 152) |
| 1. | Thallus not convolute | 2 |
| 2. | Gas vacuoles present | 2. *M. marssonii* (p. 154) |
| 2. | Gas vacuoles absent | 3 |
| 3. | Cells up to 2½ times longer than broad | 1. *M. convoluta* (p. 152) |
| 3. | Cells as long as or shorter than broad | 4 |
| 4. | Cells up to 3.5 μ broad | 5 |
| 4. | Cells broader | 6 |
| 5. | Cells 0.5 – 0.8 μ broad | 3. *M. minima* (p. 154) |
| 5. | Cells 1.3 – 2 μ broad | 4. *M. tenuissima* (p. 154) |
| 5. | Cells 2.5 – 3.5 μ broad | 5. *M. punctata* (p. 155) |
| 6. | Cells 3 – 6 μ broad | 6. *M. glauca* (p. 155) |
| 6. | Cells 5 – 7 (–10) μ broad | 7. *M. elegans* (p. 156) |
| 6. | Cells about 5 μ broad | 8. *M. aeruginea* (p. 156) |

### 1. **Merismopedia convoluta** Bréb.

in Kützing, Species Algarum, 472, 1849; Tab. Phycologicae, 5: pl. 38, fig. 9, 1856; Forti in De Toni, Sylloge Algarum, 5: 108, 1907; Geitler, Kryptogamenflora, 262, 1932; Frémy, Cyano. cotes d'Eur., p. 8, pl. 1, fig. 4, 1933.

Pl. 29, Figs. 8, 12, 13

Cells spherical to oblong, 4–5.2 μ broad, sometimes (8–) 9–11.7 μ long, rarely longer, forming a large 1–4 mm long and broad, flat, often leaf like convolute colonies; blue-green, olive-green or yellowish.

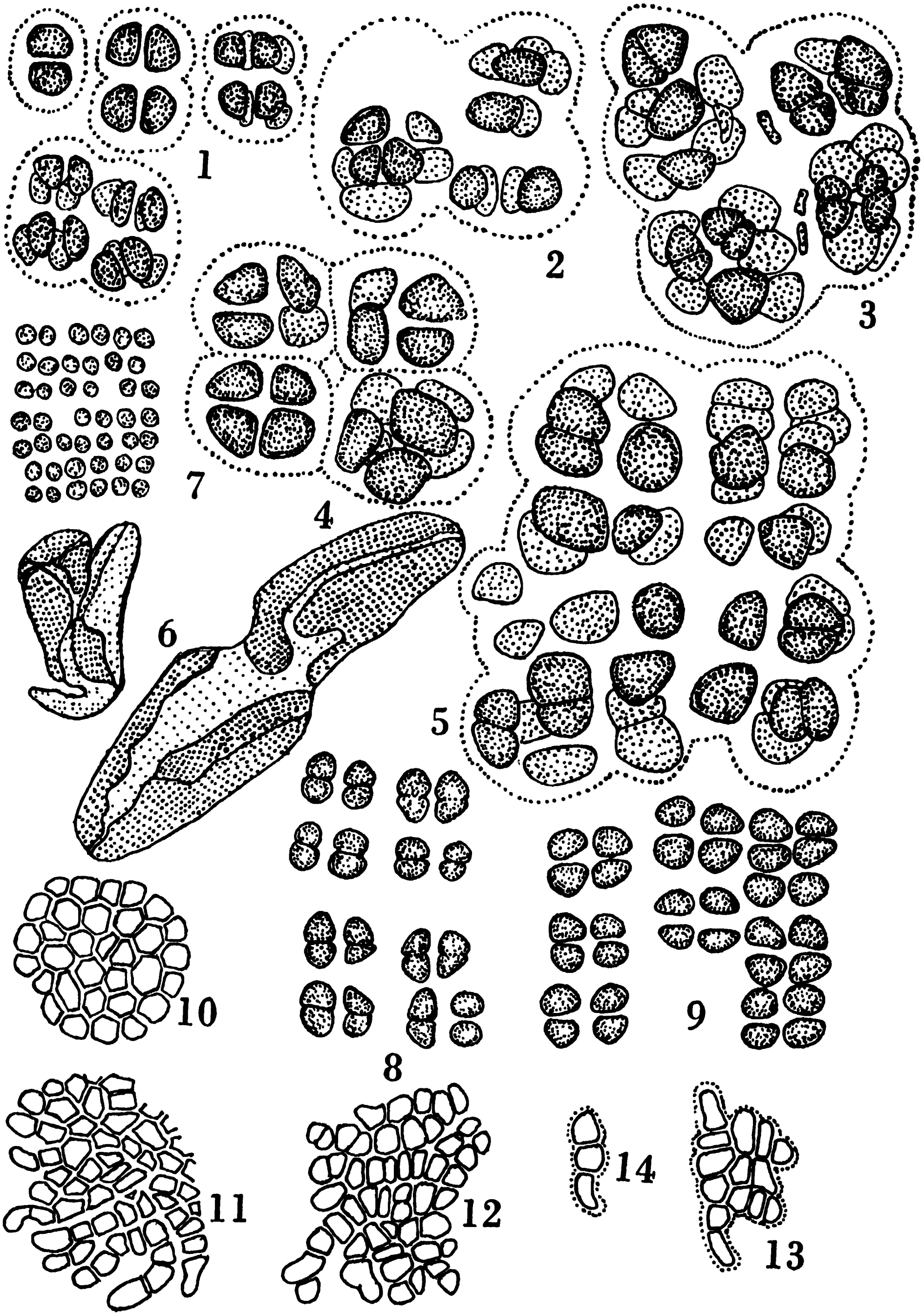

PLATE 30, Figs. 1–14.

1–5. *Myxosarcina spectabilis* Geitler (orig.); 6, 7. *Merismopedia tenuissima* forma (orig.); 8, 9. *M. tenuissima* Lemm. (orig.); 10–14. *Hydrococcus rivularis* Kütz. (after Geitler).

In temporary microphytoplankton of the river Hooghly, Calcutta (Biswas, 1942, 198).

Frémy (1933) includes *M. gigas* Ryppowa in this species.

### 2. **Merismopedia marssonii** Lemmermann

Beitr. Kenntnis Planktonalg., III, Ber. dtsch. bot. Ges., 18: 31, 1900; Kryptogamenflora der Mark Brandenburg, 3: 86, 1910; Forti in De Toni, Sylloge Algarum, 5; 107, 1907; Frémy, Myxo. d'Afr. équat. franc., 15, 1929; Geitler, Kryptogamenflora, 265, 1932.

Pl. 29, Fig. 15

Cells spherical to subspherical, 1.3–2 μ broad, colony rectangular, with 16–128 cells, gas vacuoles present.

Planktonic in an artificial pond, Madras ( ! ).

The cells in the Madras form were 1.3–2 (3.3) μ broad.

### 3. **Merismopedia minima** Beck

in Beck and Zahlbruchner, Shedae ad Krypto. exsicc., Cent. III, n. 227, in Ann. K. K. Naturhist. Hofmus., 12: 83, 1897; Forti in De Toni, Sylloge Algarum, 5: 108, 1907; Geitler, Kryptogamenflora, 263, 1932.

Pl. 29, Fig. 11

Cells pale blue-green 4 to many in small colonies, 0.5–0.6 μ broad, free swimming, groups of four cells 2–3 × 3 μ.

Planktonic in artificial tank, Benaras (Rao, C. B., 1936, 167), Ellore (Rao, C. B., 1938a, 83), Bombay (Beck, *loc. cit.*), and Burma (Skuja, 1949, 20).

Skuja recorded the species earlier from Lettlands and the Burmese form which he reported agrees very closely with the former. In the Burmese form the colonies consisted of 4–32 cells which were 0.5–0.7 μ broad.

Rao, C. B. (1937b, 346) described a form from Benaras, with the cells 0.2–0.4 μ broad and forming colonies with up to 320 cells.

### 4. **Merismopedia tenuissima** Lemm.

Beitr. Kennt. Planktonalg., II, Bot. Centralbl. 76; 154, 1898; Kryptogamenflora der Mark Brandenburg, 3: 82, fig. 8, 1910; Forti in De Toni, Sylloge Algarum, 5: 108, 1907; Frémy, Myxo. d'Afr. équat. franc., 11, fig. 7, 1929; Geitler, Kryptogamenflora, 263, fig. 129a, b, 1932; Frémy, Cyano. cotes d'Eur., 6, pl. 1, fig. 3, 1933.

Pl. 29, Fig. 7 & Pl. 30, Figs. 8, 9

Cells pale blue-green closely packed in colonies of 16–100 cells, subspherical, 1.3–2 μ broad, sometimes individual cells with distinct mucilaginous envelopes.

In Plankton, at Candy and Colombo, and Beira lake, Nuwarawewa tank and Gregory lake (Crow, 1923b, 140; Skvortzow, 1928, 109; Holsinger, 1954, 9) in Ceylon and at Benaras (Rao, 1937b, 246); Coconada, Ellore, Polamur, Veereswaram (Rao, C. B., 1938a, 83); Berhampur (Rao, C. B., 1938b, 159); and Delhi (Rao, C. S., 1940, 126) in India.

Rao, C. B. (1938a, 83) and Rao, C. S. (1940, 126) have described the cells in their specimens being 2.5–3.2 μ diam. In Plate 30, figures 6 and 7 is represented a form found growing along with *Stigeoclonium* in a pond at Madras which has a very large thallus and the cells do not have individual envelopes (cf. G. M. Smith, Roosevelt Wild Life Bull. 2: 94, pl. 3, fig. 35, 1924; also Geitler, fig. 129b, 1932).

### 5. **Merismopedia punctata** Meyen

in Wiegmann, Archiv., 2: 67, 1839; Kützing, Tab. Phycologicae, 5: pl. 38, fig. 5, 1855; Forti in De Toni, Sylloge Algarum, 5: 106, 1907; Frémy, Myxo. d'Afr. équat. franc., 12, fig. 8, 1929; Geitler, Kryptogamenflora, 263, fig. 129c, 1932.

Pl. 23, Fig. 5 & Pl. 29, Fig. 6

Colonies small, 4–64 cells, about 60 μ broad; cells not closely packed, spherical or ovoid, 2.5–3.5 μ broad, pale blue-green.

Plankton in stagnant and flowing waters or among other algae.—Pandure (Crow, 1923, 1923b, 140) in Ceylon; Delhi (Rao, C. S., 1940, 126); Madras (Ganapathi, 1940a, 246); Punjab, Chamba state (Singh, V. P., 1941, 251); and in a stream at Vaiyampatti, near Trichinopoly ( ! ).

Rao, C. S. (1940, 126) reports colonies with up to 62.5 μ broad and up to 115.5 μ long.

### 6. **Merismopedia glauca** (Ehrenb.) Näg.

Gatt. einzell. Algen, 55, pl. 1D, fig. 1, 1849; Forti in De Toni, Sylloge Algarum, 5: 105, 1907; Frémy, Myxo. d'Afr. équat. franc., 13, fig. 9, 1929; Geitler, Kryptogamenflora, 264, fig. 129d, 1932; Frémy, Cyano. cotes d'Eur., 7, pl. 1, fig. 2, 1933.

Pl. 29, Fig. 5

Colonies mostly small with 16–64 cells, rarely more, 45–150 μ diam., cells oval or spherical, closely arranged, 3–6, μ broad, pale blue-green.

In Plankton in standing waters and among algae, in irrigation channels and fast running streams, shallow pools, in mangrove swamps.—Bombay (Beck and Zahlbruchner, 1897, 83), N. India (Turner, 1892, 12), Calcutta (Banerji, 1936, 299); Madras (Ganapathi, 1940a, 246) in India; Perediniya, Pandure (West and West, 1907, 242) and Anuradhapura, Newarawewa, Bentotle etc. (Crow, 1923b, 140) in Ceylon and in Rangoon, Burma (Skuja, 1949, 20).

Rao, C. S. (1939, 143) described a form from Dharbanga, Bihar which differs in having larger number of cells (80, rarely 320), in each colony (cf. f. *mediterranea* (Näg.) Collins.).—Colony 75–85 μ diam., 100–110 μ long, cells 4.5–5.5 μ broad (Pl. 29, Fig. 10). Similarly Gupta (1956, 76) reports colonies with up to 512 cells from Allahabad.

### 7. **Merismopedia elegans** A. Br.

in Kützing, Species Algarum, 472, 1848; Tab. Phycologicae, 5: pl. 38, fig. 1856; Forti in De Toni, Sylloge Algarum, 5: 104, 1907; Frémy, Myxo. d'Afr. équat. franc., 13, fig. 11, 1929; Geitler, Kryptogamenflora, 265, fig. 129e, 1932; Frémy, Cyano. cotes d'Eur., 7, pl. 1, fig. 3, 1933.

Pl. 29, Fig. 9

Colonies small or big, 16–4000 celled, cells spherical or oblong, more or less closely arranged, 5–7 μ broad, and (5–) 6–9 μ long; light blue.

In Plankton generally.—Lake at Maduganga at Ceylon (Crow, 1923b, 140); river Dihang, at Hotung, Sukat (Carter, 1926, 267); Calcutta (Banerji, 1936, 299); Hyderabad (Ghousuddin, 1936, 149); in the river Hooghly (Biswas, 1942, 198) in India.

Banerji (*loc. cit.*) described the colonies as greenish and having 64–1024 cells.

### 8. **Merismopedia aeruginea** Bréb.

in Kützing, Species Algarum, 472, 1849; Tab. Phycologicac, 5: pl. 38, fig. 8, 1856; Forti in De Toni, Sylloge Algarum, 5: 107, 1907; Frémy, Myxo. d'Afr. équat. franc., 13, fig. 10, 1929.

Pl. 20, Fig. 3

Thallus more or less limited, 4–64 cells in a colony, colonies 35–68 μ broad; cells spherical about 5 μ broad, contents blue-green.

On the banks of the Irrawady river, near Bhamo, Burma (West and West, 1902, 242).

Elenkin (1938, 81) includes this under *M. glauca* (Ehrenb.) Näg.

## **EUCAPSIS** Clements et Shantz.

Minn. Bot. Stud., 4: 134, pl. 2, fig. 38, 1909.

Cells spherical or elliptical, in colonies of 32–128 arranged in cubical patterns in sets of fours, in three directions at right angles to each other, multiplication by divisions in three directions; in free-floating colonies.

Type species: *E. alpina* Clements et Shantz.

Lund, J. W. G. (Naturalist, London, 1950, 143) observed movements of cells in *Eucapsis alpina.*

Only one species reported so far from the region.

### **Eucapsis minuta** Fritsch

Freshwater algae, Nat. Antarct. Exp., Nat. Hist., 6: 25, pl. 1, figs. 47, 48, 1912; Geitler, Kryptogamenflora, 258, fig. 127, 1932.

Colonies large, with regular contours, 8–32–128 cells, rarely more, free-swimming with thick hyaline mucilage; cells spherical 2–4 together, pale blue-green in color, closely arranged when young and becoming loose in old colonies, 1–1.5 μ broad.

Singh, H. D., (1933, 106) mentions this species as occurring in cultures of soil from Lahore. Drouet and Daily (Rev. Coccoid Myxo., 150, 1956) have rejected the species as bacteria. As Singh does not give any description or figures of the Lahore alga it is difficult to decide its exact identity.

## **DACTYLOCOCCOPSIS** Hansgirg

Syn. gen. subgen. Myxophyceae, Notarisia, 3: 590, 1888.

Cells cylindrical or ellipsoidal with pointed ends, spindle-shaped, straight or more or less bent in the form of a ' S ', seldom single, but generally a few together, without forming a definite free-swimming colony; multiplication by transverse, rarely oblique division.

Type species: *D. rupestris* Hansgirg.

The genus resembles very much the green alga *Ankistrodemus.*

Three species are known.

### KEY TO THE SPECIES

1. Cells spindle-shaped, colony free-swimming .............................. 2
1. Cells broadly ellipsoidal to spindle-shaped in the mucilage of animals
   1. *D. pectinatellophila* (p. 158)
   2. Cells single or many in colonies, not compact.... 2. *D. raphidioides* (p. 158)
   2. Cells many together in fasciculate colonies...... 3. *D. fascicularis* (p. 158)

### 1. **Dactylococcopsis pectinatellophila** W. West.

Journ. Proc. asiatic Soc. Bengal, 7: 83, 1911; Geitler, Kryptogamenflora, 286, fig. 140d, 1932.

Pl. 29, Fig. 4

Cells broadly ellipsoidal or spindle-shaped, 3–5.5 μ broad and 8–13 μ long, light blue-green.

In the mucilage of a Bryozoon, *Pectinella burmanica*, encasing the reeds growing in the shallow middle of the Sur lake, Puri, Orissa.

### 2. **Dactylococcopsis raphidioides** Hansg.

Syn. gen. subgen. Myxo., Notarisia, 590, 1888; Forti in De Toni, Sylloge Algarum, 5: 31, 1907; Frémy, Myxo. Afr., équat. franc. p. 6, fig. 1, 1929; Geitler, Kryptogamenflora, p. 281, fig. 137, 1932.

Pl. 29, Figs. 1, 2

Cells spindle-shaped, sigmoid or lunulately bent, 1–3 μ broad, 5–6–8 times as long as broad, up to 25 μ long, light blue-green, single to a few together in a little mucilage.

The species is highly polymorphic, and the type form has so far not been recorded from India. Rao, C. B. (1937b, 347) described a form — cells falciform, 1.6–2 μ broad, 2–35 (–40) μ long — in a pond on the University gardens, Banares. The alga differs from the type and also f. *falciformis* Printz in the cells being longer.

### 3. **Dactylococcopsis fascicularis** Lemm.

Beitr. zur Kenntnis der Planktonalgen, Bot. Centralbl., 76: 153, 1898; Kryptogamenflora der Mark Brandenburg, 3: 50, fig. 4 (p. 44), 1910; Forti in De Toni, Sylloge Algarum, 5: 32, 1907; Geitler, Kryptogamenflora, 283, fig. 138b, 1932.

Pl. 29, Fig. 3

Cells spindle-shaped with a long narrow pointed apex many together in a free-swimming bundle, 1 μ broad, up to 55 μ long, blue-green.

Type not recorded so far from India.

### f. **indica** f. nov.

Pl. 29, Fig. 16

Cells up to 50 cells, in free-swimming bundles, bent or arcuate, ends tapering, 1.3–2.6 μ broad, up to 55 μ long, blue-green.

Among other algae in a tank in Kanchipuram; in a tank at Anantapur Shimoga dist., Mysore state; in a lake at Yercaud. The form showed constant characters in all the collections.

## Family ENTOPHYSALIDACEAE Geitler

Synopt. Darst. Cyano., Beih. bot. Cbl., 41 (Abt. 2): 235, 1925; Kryptogamenflora, 292, 1932.

Thallus generally attached, in some free-floating; cells arranged in erect radial rows, rarely in irregular rows or groups or without the formation of a typical filament, sometimes with a prominent one sided development of a sheath forming a mucilaginous filamentous stalk with a cell or groups of cells at the apices; cells spherical or ellipsoidal seldom cylindrical, often in a homogeneous mucilage with or without individual sheaths; sheath narrow or broad; nannocytes known; spores also present.

Geitler (1925) placed the Entophysalidaceae in an order Entophysalidales along with Chlorogloeaceae. He, however, abolished the separate order in 1932 and included it in the Chroococcales. Elenkin (1936, 1938) separates *Johannesbaptistia* (*Cyanothrix*) and *Tubiella* into Tubiellaceae under Tubiellales. He places in the Entophysalidaceae the rest of the members of the Entophysalidaceae. The Entophysalidaceae have such a great resemblance in the structure of the cell, colony etc., to the coccoid forms, that the family may be retained in the Chroococcales itself as representing the development of a filamentous tendency (*see* Iyengar and Desikachary, 1946). Its position is very similar to the Tetrasporales in the overall evolution of the filamentous forms.

Drouet and Daily (1956) have reduced all the genera to one genus, *Entophysalis*, and have included the same in the Chamaesiphonaceae. They include *Johannesbaptistia* under the Chroococcaceae.

### KEY TO THE GENERA

1. Cells in a single row forming a pseudofilamentous cylindrical thallus *Johannesbaptistia* (p. 163)
1. Cells in more than a single row, thallus not cylindrical .................... 2
    2. Cells with vesicular sheath as in *Gloeocapsa* .......................... 3
    2. Cells with sheaths not like those of *Gloeocapsa*, with a thin sheath or without individual sheaths, in a more or less homogeneous gelatinous thallus, cells in distinct radial rows ........................ *Chlorogloea* (p. 162)
3. Cells in distinct rows, thallus crustaceous ................ *Entophysalis* (p. 160)
3. Cells in distinct rows, thallus gelatinous, rounded or irregularly folded and hollow *Placoma* (p. 160)

### ENTOPHYSALIS Kütz.

Phyc. generalis, 177, 1843.

Thallus broad and expanded, crustaceous; cells with a broad swollen mucilaginous sheath as in *Gloeocapsa*, cells or groups of cells after division in straight rows. Spores known.

Type species: *E. granulosa* Kütz.

The genus resembles *Gloeocapsa* generally, but differs in the arrangement of the cells in distinct rows, which is clear especially in the younger stages. The arrangement is nearly lost in the older ones.

In *E. granulosa* the upper cells may develop a very thick wall and become converted into spores very similar to those seen in *Gloeocapsa* (Kirchner, 1898, p. 53, fig. 49g).

One species known from the region.

**Entophysalis granulosa** Kützing.

Phyc. gene., 177, pl. 18, fig. 5, 1843; Tab. Phycologicae, 1: 22, pl. 32, fig. 1, 1846; Forti in De Toni, Sylloge Algarum, 5: 58, 1907; Geitler, Kryptogamenflora, 298, fig. 146, 1932; Frémy, Cyano. cotes d'Eur., 32, pl. 6, fig. 5, 1933.

Pl. 19, Fig. 7 & Pl. 29, Fig. 14.

Thallus crustaceous, up to 1 mm. thick, dark brownish, granular, verrucose, cartilaginous; cells without sheath 2–5 μ diam.; sheath colorless yellow to brown, lamellated; spores present.

On dead corals near Pamban (Iyengar and Desikachary, 1944, 39); on pebbles and rocks, cape Comorin (Venkatraman, 1957, 472).

The cells in the Pamban plants are 2.6–3.9 μ diam.

The mucilaginous sheaths in the inner part of the thallus are colorless, gelatinizing and diffluent, so that the linear arrangement is not clear. The cells in the outer or marginal portions of the thallus clearly show the linear arrangement.

The spores are very well illustrated by Kirchner (1898, p. 53, fig. 49 g; *see* also Bornet and Thuret, Notes algologiques, 1: pl. 1, 1876).

### PLACOMA Schousboe

in Bornet & Thuret, Notes algologiques, 1: 4, 1876.

Thallus gelatinous, hemispherical or irregularly folded, hollow, in the inside, when old expanded; cells in soft balloon shaped concentric sheaths,

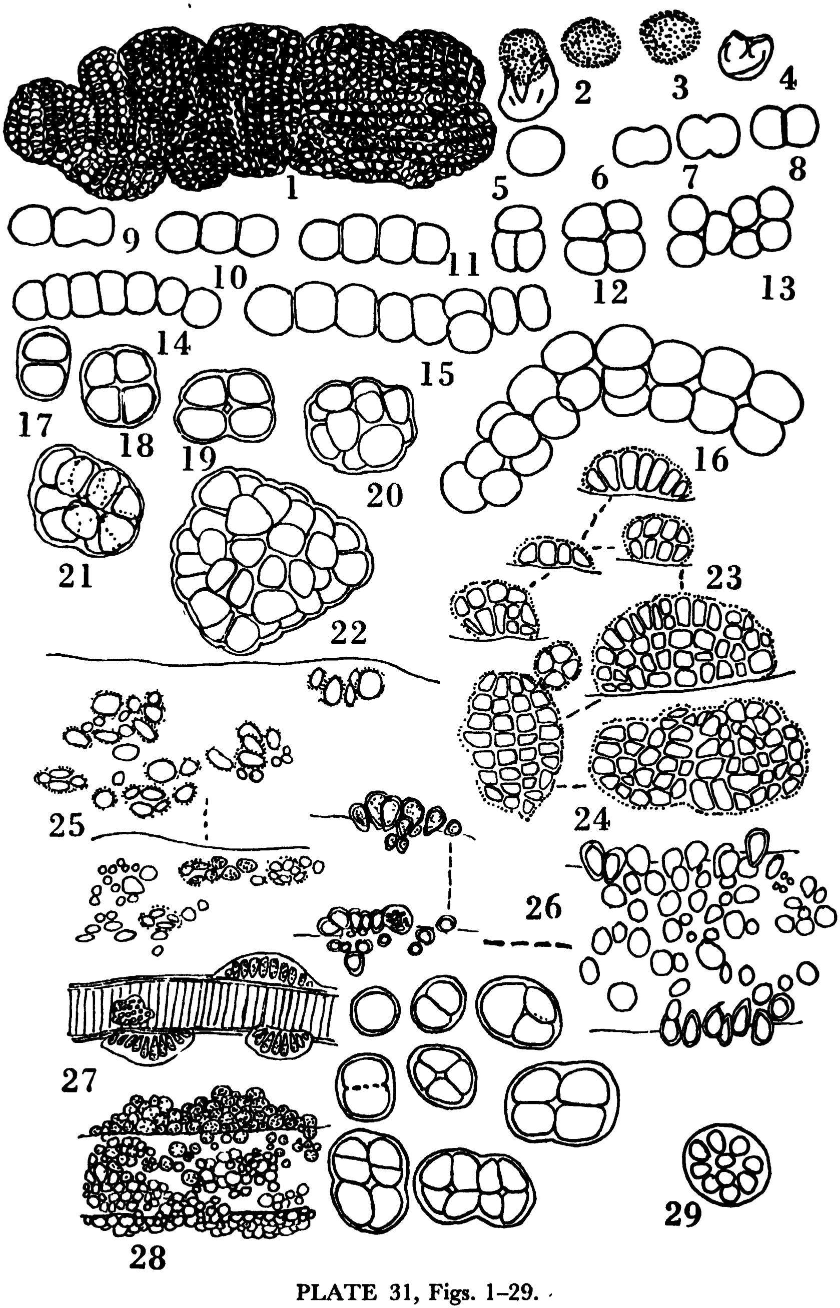

PLATE 31, Figs. 1–29.

1–16. *Chlorogloea fritschii* Mitra (after Mitra); 17–22. *Myxosarcina spectabilis* Geitler (after Geitler); 23–24. *Xenococcus kerneri* Hansg. (after Geitler); 25. *Xenococcus chaetomorphae* Setchell et Gardner (after Iyengar and Desikachary); 26. *X. cladophorae* (Tilden) Setchell et Gardner (after Desikachary); 27. *X. kerneri* Hansg. (after Hansgirg); 28. *X. acervatus* Setchell et Gardner (after Setchell and Gardner); 29. *Chroococcidiopsis indica* n. sp. (orig.).

forming *Gloeocapsa*-like daughter colonies, cells at the periphery more or less distinctly radially arranged.

Type species: *P. vesiculosa* Schousboe.

One species known from the region.

### **Placoma vesiculosa** Schousboe

ex Bornet & Thuret, Notes algologiques, 1: 4, pl. 1, figs. 6–10, 1876; Forti in De Toni, Sylloge Algarum, 5: 59, 1907; Geitler, Kryptogamenflora, 300, fig. 148, 1932; Frémy, Cyano. cotes d'Eur., 33, pl. 7, fig. 1, 1933.

Pl. 27, Figs. 1, 2.

Cells without sheath about 4 μ diam.; sheath at the periphery of the thallus firm, mostly colored yellow or brown, in the inside gelatinized or diffluent, soft colorless.

Rangoon (Skuja, 1949, 20).

Skuja (1949, 20) recorded a form of *Placoma* growing on bricks in cantonment, Rangoon, which according to him resembles mostly *P. vesiculosa* and to a lesser degree *P. africana* Wille. So the identification of the species is only tentative.

## CHLOROGLOEA Wille

Algol. Notizen, I-VI, Nyt Mag. Naturvid., 38: 5, 1900.

Cells spherical or ellipsoidal mostly without individual envelopes or with a thin unlamellated sheath, in a common mucilage, in straight erect or radial rows, rows sometimes indistinct, forming more or less hemispherical or flat irregularly lobed thalli, sometimes with daughter colonies; cell division in three directions but generally in a single determined direction; gonidia and nannocytes present.

Type species: *Chl. tuberculosa* (Hansgirg) Wille.

The genus is definitely of Chroococcaceen affinity. Young stages (Mitra, 1950, 457) reveal that the thallus has essentially a pseudofilamentous condition and hence it forms a link in evolution of the Pleurocapsales from the coccoid ancestor.

### KEY TO THE SPECIES

1. Cells 2–3.8 μ diam. .................................. 1. *Chl. microcystoides* (p. 163)
1. Cells 6–8 μ diam. .................................. 2. *Chl. fritschii* (p. 163)

### 1. **Chlorogloea microcystoides** Geitler

Neue Cyano. Gruppe Chamaesiphon., Arch. Protistenk., 51: 359, fig. U, 1925; Kryptogamenflora, 310, fig. 155, 1932.

Pl. 19, Fig. 8.

Thallus thin, gelatinous, forming a slightly lobed dull green to brownish crust mostly hemispherical or larger thallus made up by the union of a number of daughter colonies; cells spherical, or ellipsoidal, mostly very closely arranged and polygonal in erect or radial rows of branched or more or less indistinct rows, generally without a distinct individual sheath; colonial mucilage colorless, or yellowish to brownish only in peripheral parts; cells 2–3.8 µ diam., blue-green, olive green or yellowish; nannocytes formed in somewhat broader cells by repeated divisions, 1.5–2 µ diam.

On stones, pebbles and boulders in the bed of a stream, Kalijhora, in Assam, (Biswas, 1936, 121); epiphytic, Mandalay, Burma (Skuja, 1949, 21).

The cells in the Assamese alga are 1.5–4.8 µ diam., according to Biswas.

### 2. **Chlorogloea fritschii** Mitra

Two new algae from Indian Soils, Ann. Bot., Lond., n. s., 14; 457, figs. 25–43, 1950.

Pl. 31, Figs. 1–16.

Thallus a deep blue green crust of indefinite size, composed of rounded or irregular cell packets; cells arranged in vertical and horizontal rows, rounded or angular, without evident mucilage envelopes, with pale blue-green, granular contents, usually 6–8 µ diam. (4–12 µ), single or in groups of two or more cells separating for propagation; endospores naked, spherical, 4–9 µ diam., formed singly within the cells and liberated by the rupture of the membrane, on germination forming a uniseriate filament of 3–12 cells which divide in three directions to produce packets.

In soils from wheat fields, Allahabad (Mitra, 1950, 457; 1951, 359).

## JOHANNESBAPTISTIA J. de Toni

Noter. Nomencl. Algol., 1: 6, 1936.

= *Cyanothrix* Gardner, Mem. N. Y. Bot. Gard., 7: 30, 1927, *non* Schmidle

= *Heterohormogonium* Copeland Ann. N. Y. Acad. Sci., 36: 64, 1936.

Thallus microscopic, linear, elongated, cylindrical, straight, or curved; cells discoid arranged in a single series, in narrow cylindrical hyaline mucilage,

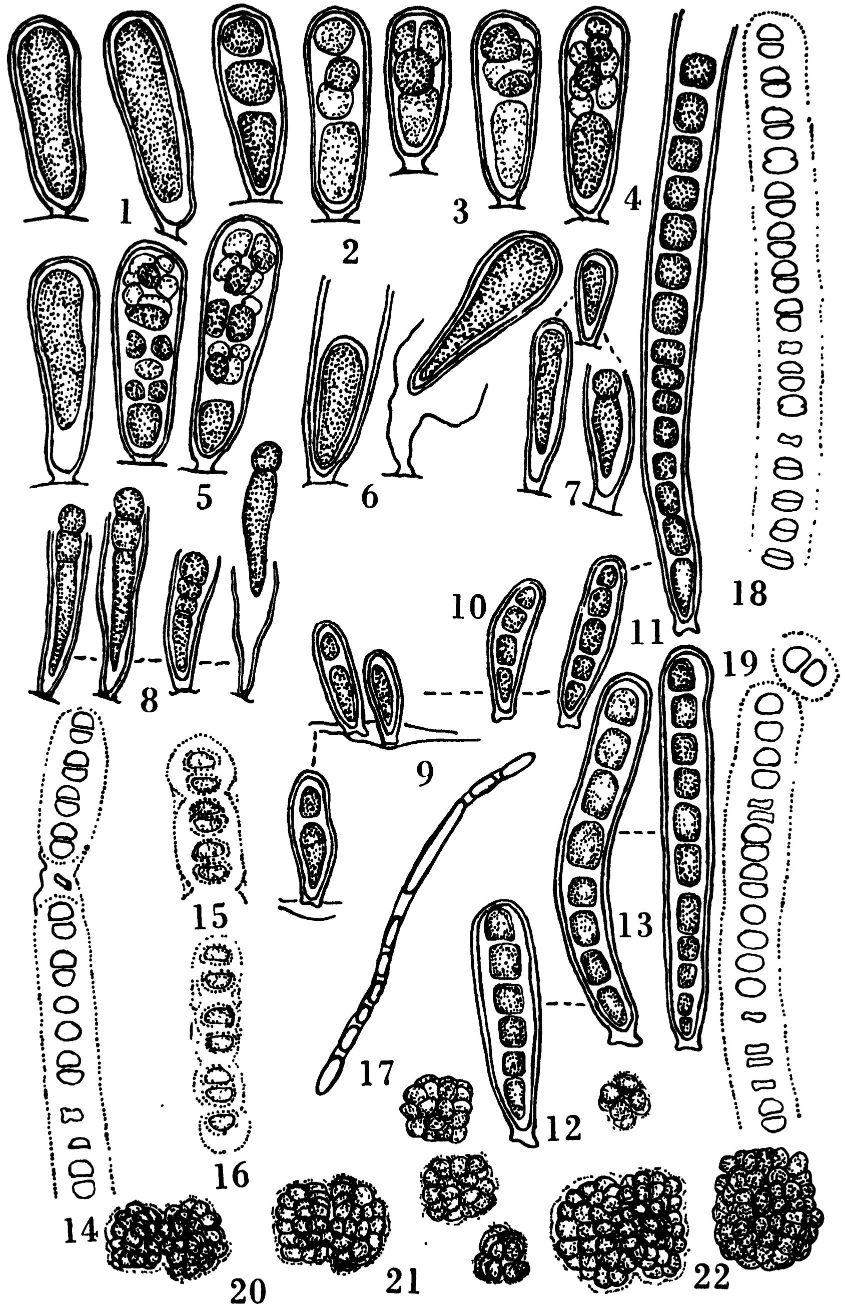

PLATE 32, Figs. 1–22.

1–4. *Dermocarpa clavata* Geitler (orig.); 5, 6. *D. clavata* forma (orig.); 7, 8. *Chamaesiphon rostaffinskii* (Rostaf.) Hansg. (orig.); 9–13. *Stichosiphon sansibaricus* (Hieron.) Drouet et Daily (orig.); 14–19. *Johannesbaptistia pellucida* (Dickie) Taylor et Drouet (after Iyengar and Desikachary); 20–22. *Myxosarcina burmensis* Skuja (after Skuja).

division in one plane, transverse to the thallus; propagation by fragmentation into pieces of one to few cells.

Type species: *J. pellucida* (Dickie) Taylor and Drouet.

This genus was first described by Gardner as *Cyanothrix* a later homonym of Schmidle's *Cyanothrix* and J. de Toni renamed it *Johannesbaptistia.*

Gardner described two species, *J. primaria* and *J. willei.* Frémy (1935) included the two species under one, *J. gardneri.* Taylor and Drouet examining the original specimen of *Hormospora pellucida* Dickie found it is the same as *Johannesbaptistia.* Hence only one species has been recognised by most workers, *J. pellucida* (Dickie) Taylor & Drouet.

*Cyanothrix cavanillesii* Gonz.-Guerr. (Algas invernales gaditanas, Ann. Jard. Bot. Madrid, 7: 442, pl. 2, fig. 2, 1947), is a short form with 10–14 cells, the cells being 4–4.5 μ diam. Such short filaments can be formed by fragmentation (*see* Iyengar and Desikachary, 1946).

Kisselew (1947) described a *Johannesbaptistia* which shows some sort of branching and thus resembles *Heterohormogonium* Copeland. There is a large amount of resemblance between the two genera and it is possible as has been described by Kisselew that such branching can be derived by the continued growth of the fragmented portion remaining attached to the parent filament.

Frémy (1935), Seurat and Frémy (1937) and Frémy and De Toni, G., (Atti del R. Istituto Veneto di Scienze, Lett. Art. Sci. mat. e nat., 99(2): 401–406, 1939–40), draw some sort of similarity between a pathogenic condition of a species of *Lyngbya* and *Johannesbaptistia* and consider the later as a biological variant. The absence of discs of intercellular substances in *Johannesbaptistia* and the absence of the relevant species of *Lyngbya* in the corresponding localities (Drouet and Daily, 1956, 86) are against Frémy's conclusion that it is not an independent blue green algal genus.

**Johannesbaptistia pellucida** (Dickie) Taylor et Drouet

Bull. Torrey bot. Cl., 65: 285, 1938; Drouet and Daily, Rev. Coccoid Myxophyceae., Butler Univ. Stud. Bot., 12: 85, figs. 182–184, 1956.

Pl. 32, Figs. 14–19.

Filaments blue-green or olivaceous, straight or curved, about 2.5 mm. long, (–3) 7.9–10.8 (–20) μ broad; cells discoid or sphaerico-discoid, round at the apices of the filaments, arranged in a single series, in a cylindrical hyaline mucilage, cells 3.9–5.2 μ broad and 2.6–3.9 μ long; mucilage homogeneous, sheath round the cell visible after division, firm or diffluent; contents blue-green, olivaceous, homogeneous or granular.

Among other algae in brackish water pools or in estuarine portions of a river near Madras (Iyengar and Desikachary, 1946b, 117; Rao, C. B., 1947, 63).

# Order CHAMAESIPHONALES R. v. Wettstein

Handbuch d. Syst. Bot., 3: 79, 1923 (p.p.).

= *Dermocarpales* Geitler, Synopt. Darst. Cyano., Beih. bot. Cbl., 2 (abt. 2): 41: 247, 1925.

Unicellular, often occurring gregariously through endospores or exospores, often with a differentiation of base and apex.

Geitler first (1925) separated the Dermocarpales from the Pleurocapsales, but in 1932 following Wettstein he again united them into one order. In 1942, however, he reverted to the older classification of placing the filamentous attached forms into Pleurocapsales. Fritsch (1942, 1945) lays great stress on the heterotrichous condition in many of the genera included under the Pleurocapsales and suggests a possible connection to the Stigonematales.

### KEY TO THE FAMILIES

1. Plants free living .......................................... *Cyanidiaceae* (p. 166)
1. Plants attached with a differentiation of base and apex .......................... 2
    2. With exospores .............................. *Chamaesiphonaceae* (p. 167)
    2. With endospores .............................. *Dermocarpaceae* (p. 171)

## Family CYANIDIACEAE Geitler

Arch. Hydrobiol. (u. Planktonk.), suppl. 12: 624, 1933.

Cells spherical, not differentiated into base and apex, single or in groups, transforming without division into a sporangium; vegetative division absent; reproduction by endospores and pseudoendospores.

A single genus known.

### **CHROOCOCCIDIOPSIS** Geitler

Arch. Hydrobiol. (u. Planktonk.), suppl. 12: 4: 625, 1933; Geitler and Ruttner, ibid., 14: 391, figs. 12, 17, 1935.

Cells more or less spherical with a narrow firm membrane, single, or in groups becoming transformed into sporangia; cells formed by the formation of endospores, by the repeated division of the entire contents and the gelatinization of the mother wall; vegetative division absent; endospore formation by division in three directions, up to 32 endospores.

Type species: *C. thermalis* Geitler.

Drouet and Daily (1956, 35) place this genus under *Anacystis* and the type species itself under *A. montana* f. *montana* Dr. and D.

One species known.

### **Chroococcidiopsis indica** sp. nov.

Pl. 31, Fig. 29

Cells solitary, rarely many together spherical or subspherical, 5.3–6.5 μ broad, with a firm wall, endospores 8–12 formed by successive division.

Among other algae in a tub, in the laboratory, Madras ( ! ).

The species differs from the type species *C. thermalis* Geitler in the dimensions of the alga, in the number of endospores and in being non-thermal.

## Family CHAMAESIPHONACEAE Borzi

Morf. biol. ficocr., N. Giorn Bot. ital., 14: 298, 1882.

Plants single attached with differentiation into base and apex or forming a colony by the development of exospores attached to the mother cell; cells when young club-shaped, later elongate and becoming a sporangium; cell wall or sporangial wall when old breaks at the apex and remains as a membrane or pseudovagina around the protoplast; reproduction by the formation of exospores abstricted continuously from the apex of the sporangium in basipetal succession.

A single genus known from the region.

### **CHAMAESIPHON** A. Br., et Gurnow,

in Rabenhorst, Fl. Eur. Alg., 2: 148, 1865; em. Geitler, Synopt. Darst. Cyano., Beih. bot. Cbl., 41 (2) : 256, 1925.

Sporangia with a short mucilage stalk or without such a stalk, attached by a mucilage disc; at first spherical, later ellipsoidal, club-shaped, or cylindrical, abstricting exospores at the apex; membrane lamellated, the wall opening at the tip and the rest remaining as pseudovagina or sometimes gelatinizing; pseudovagina firm or gelatinous, colorless or yellow to brown; exospores sometimes remaining attached at the apex of the sporangium and germinating, forming a filamentous or denroid colony.

Type species: *Ch. confervicola* A. Br.

Scytonemine is known in some members.

Drouet and Daily (1956) include *Ch. curvatus* (incl. var. *turneri*) and *Ch. sideriphilus* under *Entophysalis lemaniae* f. *lemaniae*, and *Ch. fuscus* under *E. rivularis* f. *papillosa* (Kütz.) Drouet and Daily. They consider that *Ch. rostaffinski* as a juvenile stage of *Amphithrix janthina* (Mont.) Born. and Flah.

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Plants forming many or few exospores, without any colony formation | 2 |
| 1. | Plants sometimes forming colonies | 1. *Ch. fuscus* (p. 168) |
| 2. | Sporangia up to 150 (-200) μ long | 2. *Ch. curvatus* (p. 168) |
| 2. | Sporangia shorter | 3 |
| 3. | With iron incrustation | 3. *Ch. sideriphilus* (p. 169) |
| 3. | Without iron incrustation | 4 |
| 4. | Pseudovagina colorless | 4. *Ch. rostaffinskii* (p. 171) |
| 4. | Pseudovagina colored | 1. *Ch. fuscus* (p. 168) |

### 1. **Chamaesiphon fuscus** (Rostaf.) Hansgirg

Oesterr. bot. Zeitschr., 38: 117, 1888; Prodromus der Algenflora von Böhmens, 2: 123, fig. 37, 1892; Forti in De Toni, Sylloge Algarum, 5: 138, 1907; Geitler, Kryptogamenflora, 436, figs. 257, 258, 1932.

Pl. 10, Figs. 1–4 & Pl. 33, Fig. 2

Thallus dull brown to blackish, mostly forming distinct flakes or crusts, with a single or many sporangia one in another; sporangia nearly cylindrical to club-shaped, 2.5–6 seldom up to 8 μ broad, 5–20 μ seldom up to 30 μ long, yellowish, olive-green or reddish on the outside, inside very pale colored; pseudovagina thick when old, firm with divergent lamellae, at the base tucked in older ones and at tip free, dirty or pure brownish to blackish brown in color; exospores 1–2 seldom more, becoming free or germinating attached to the parent plant, mostly distinctly smaller than the apex of the sporangium; colony dendroid or layered and more or less regularly zonated.

Danger Point, Bombay (Schmidle, 1900b, 162).

### 2. **Chamaesiphon curvatus** Nordst.

De Algis et Characeis Sandwicensibus, 4, pl. 1, figs. 1, 2, 1878; Frémy, Myxo. Afr. équat. franc., 69, fig. 74, 1929; Geitler, Kryptogamenflora, 426, figs. 244, 245, 1932.

Pl. 33, Fig. 1

Sporangia single or gregarious, club-shaped, or highly cylindrical more or less prominently bent, (3–) 4–6 (–13) μ broad and 20–150 (–200) μ long, pale blue-green or olive-green; pseudovagina colorless, thin, sometimes at the apex somewhat gelatinizing; exospores many formed by transverse division from the upper part only, 3–4 μ diam.

On *Bostrychia harveyi* in Coramandel Coast (Nordstedt).

### Var. **turneri** Forti

in De Toni, Sylloge Algarum, 5: 140, 1907.

Cells nearly straight.

N. India (Turner, 1892, 13).

Turner has described this as a *Chamaesiphon* sp. which Forti placed in a new variety.

### 3. **Chamaesiphon sideriphilus** Starmach

Polnische Chamae.-Arten, Acta Soc. Bot. Polon., 6: 34, pl. 1, figs. 15–28, 1929; Geitler, Kryptogamenflora, 431, 1932.

Pl. 33, Fig. 3

Sporangia single, cylindrical or short club-shaped, mostly bent, 3–5.8 seldom up to 7.5 μ broad, 12.5–61 μ long, pale blue-green or yellowish brown; pseudovagina while young colorless, but later yellow to brown owing to a rough external layer of iron incrustation on the pseudovagina; exospores mostly one, rarely 2.

Type not recorded.

Rao, C. B. (1937b, 347, fig. 2B; 1938a, 84) described a variety which differs from the type in its smaller dimensions and in the sheath being smooth and hyaline (without any calcareous impregnation ?).

### Var. **glabra** Rao, C. B.

Myxo. of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 347, fig. 2B, 1937.

Pl. 33, Figs. 6, 7

Sporangia distributed on host either singly or in dense clusters, usually club-shaped, rarely cylindrical, bent or straight, 2.4–3.2 (–4) μ broad and 4–14 μ long, with pseudovagina 3.2–3.5 μ and 4.8–17.6 (–18.4) μ long, pale blue-green with homogeneous contents; pseudovagina thin, hyaline, and smooth; exospores one, 3–3.2 μ broad.

On *Lyngbya gracilis* in a water reservoir, Benaras (Rao, C. B., 1937b, 347). On *Rhizoclonium* in a pond, Dendulur; and on *Lyngbya gracilis* Polamur, adhering to the steps submerged in a pond, (Rao, C. B., 1938a, 84); on *Stichosiphon indica* Rao (*S. sansibaricus*) and on *Cladophora* in a pond, Bai-Ka-Bag, Allahabad (Gupta, 1956, 77).

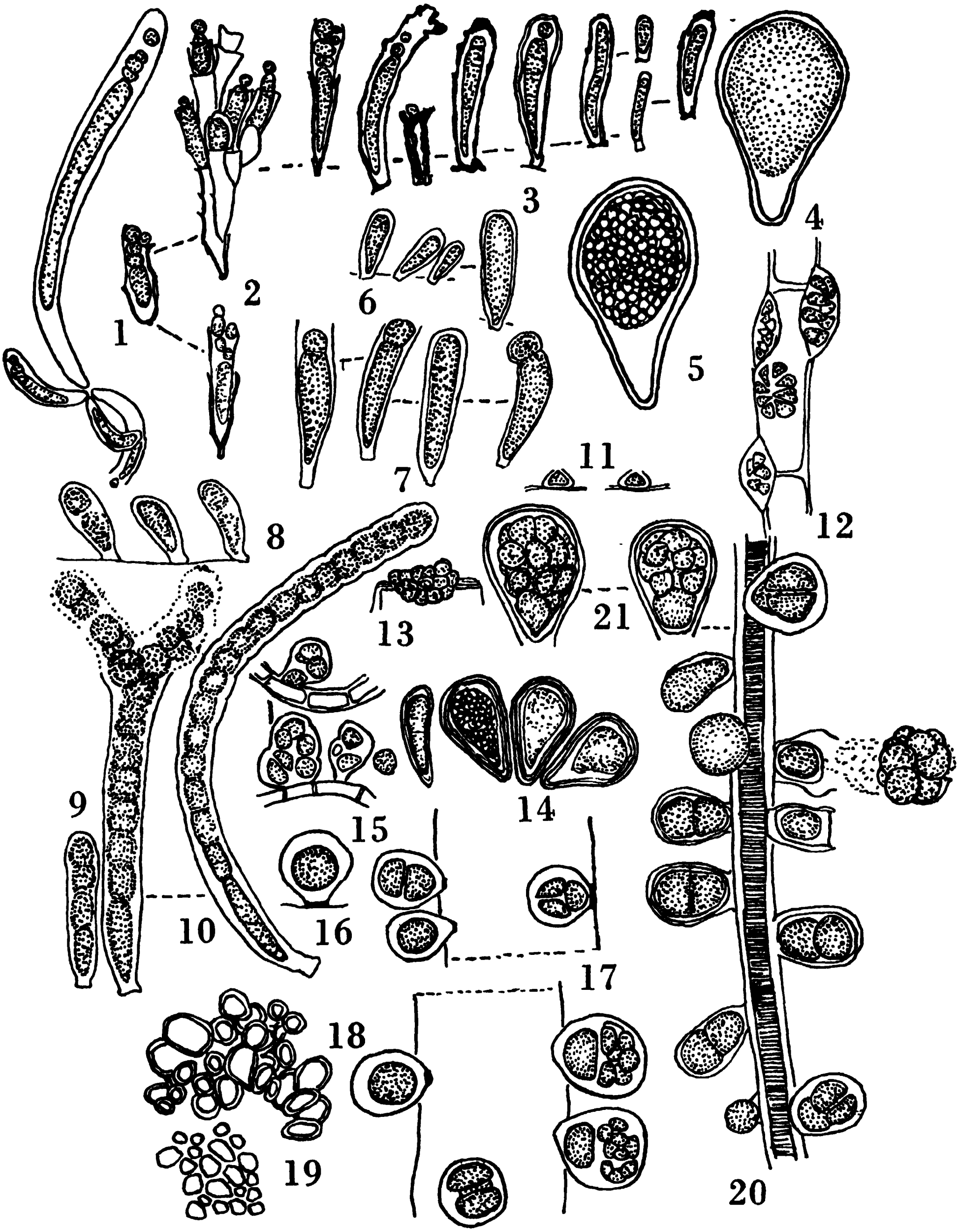

PLATE 33, Figs. 1–21.

1. *Chamaesiphon curvatus* Nordst. (after Nordst.); 2. *C. fuscus* (Rostaf.) Hansg. (after Geitler); 3. *C. sideriphilus* Starmach (after Starmach); 6, 7. *C. siderophilus* v. *glabra* Rao, C. B. (after Rao); 4, 5. *Dermocarpa olivacea* v. *gigantea* Rao, C. B. (after Rao); 11–12. *D. hemisphaerica* Setchell et Gardner (after Iyengar and Desikachary); 13–14. *D. olivacea* (Reinsch) Tilden (after Reinsch); 15. *D. leibleiniae* v. *pelagica* Wille (after Wille); 16, 17. *D. versicolor* (Borzi) Geitler (after orig.); 18, 19. *D. flahaultii* Sauv. (after Sauvageau); 20, 21. *D. leibleiniae* (Reinsch) Born. et Thuret (after Bornet and Thuret); 8–10. *Stichosiphon sansibaricus* (Hieron.) Drouet et Daily (after Skuja).

### 4. **Chamaesiphon rostaffinskii** (Rostaf.) Hansgirg

Prodromus der Algenflora von Böhmen, 2: 123, 1892; Forti in De Toni, Sylloge Algarum, 5: 137, 1907; Geitler, Kryptogamenflora, 432, 1932.

Pl. 32, Figs. 7, 8

Sporangia single or gregarious, long or short, club-shaped or cylindrical, 1–2.5 μ broad, at the apex, 2–5 μ broad, 13–21 (–45) μ long, pale rose; pseudovagina thin, colorless; exospores 1 or 2.

Epiphytic on *Lyngbya* in a pond, Saidapet, near Madras ( ! ) (Sporangia (6.6–) 9.2–15.7 μ long).

## Family DERMOCARPACEAE Geitler,

Synopt. Darst. Cyano., Beih. bot. Cbl., 41(2): 247, 1925.

Unicellular, attached, with a differentiation of base and apex; the entire contents dividing to form endospores or occasionally a basal sterile part first cut off and the rest forming endospores; vegetative division absent; sporangia more or less spherical, ellipsoidal, club-shaped, pyriform or cylindrical with a basal mucilaginous stalk or disc; wall thick, often lamellated, seldom thin or gelatinous, endospores 2 to many, mostly 8–32, formed by division in all directions, seldom in only one direction, liberated by a rupture at the apex of the sporangium, seldom by a total dissolution of the wall.

### KEY TO GENERA

1. Endospores formed by division of the protoplast in three directions *Dermocarpa* (p. 171)
1. Endospores formed by division in one direction only ......... *Stichosiphon* (p. 176)

### **DERMOCARPA** Crouan

Note sur quelques algues marines nouvelles, Ann. Sci. nat., Bot., ser. 4, 9: 70, 1858.

Cells spherical, club-shaped, oval, seldom hemispherical, attached, single or gregarious and closely packed, by transverse division a small stalk cell is cut off, mostly without a stalk or with a small mucilage stalk; endospores 4– to many by division in three directions, entire contents involved in endospore formation or a small stalk is differentiated in the beginning, liberated by the gelatinization of the sporangial wall.

Type species: *D. violacea* Crouan.

The mode of formation of endospores differs from species to species (see page 41).

Geitler at first (1932) maintains *Dermocarpella* distinct from *Dermocarpa* but later (1942) merges it into *Dermocarpa*. Feldmann, J. and G. (Observations sur les genres *Dermocarpa* et *Dermocarpella* (Cyanophyceae), Oesterr. bot. Z., 100 (4/5): 505–514, 1953) distinguish *Dermocarpa* from *Dermocarpella* Lemm. In the former the entire contents become transformed into endospores while in the latter at first the sporangium undergoes a transverse division cutting off a sterile basal portion which can ultimately form a new sporangium. Based on this they also create a new species *Dermocarpella pedicellata* which very much resembles *Dermocarpa clavata* (Setchell and Gardner) Geitler. This differentiation seems to be satisfactory generally, but species like *D. leibleiniae* offer some difficulty. In this the mode of endospore formation includes both the types. They have proposed that the genus be recognised as *Dermocarpa* Bornet and Thuret (*non* Crouan) and be typified by *Dermocarpa prasina* (Reinsch) Bornet and Thuret and have proposed that the generic name be conserved as against *Dermocarpa* Crouan on the model of *Plumaria* Schmitz *non* Stackhouse.

Drouet and Daily (1956) include most of the species described here in the genus *Entophysalis*.—*D. clavata, D. parva* and *D. versicolor* under *Entophysalis lemaniae* (Ag.) Dr. & D., f. *lemaniae* Dr. & D., *D. flahaultii* under *E. rivularis* (Kütz.) Drouet f. *rivularis* Drouet and Daily, *D. hemisphaerica, D. leibleiniae* (incl. var. *pelagica*), *D. olivacea* and *D. sphaerica* under *E. conferta* (Kütz.) Dr. & D. and *D. olivacea* var. *gigantea* Rao, C. B., under *Stichosiphon sansibaricus* (Hieron.) Dr. & D.

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Marine | 2 |
| 1. | Freshwater | 5 |
| 2. | Sporangia somewhat elongate | 4 |
| 2. | Sporangia as long as broad | 3 |
| 3. | Sporangia hemispherical | 1. *D. hemisphaerica* (p. 173) |
| 3. | Sporangia spherical | 3. *D. sphaerica* (p. 174) |
| 4. | Sporangia with a basal sterile part | 2. *D. leibleiniae* (p. 173) |
| 4. | Sporangia without a basal sterile part | 4. *D. olivacea* (p. 174) |
| 5. | Sporangia not stalked | 6 |
| 5. | Sporangia stalked | 8 |
| 6. | Sporangia regularly spherical | 7 |
| 6. | Sporangia shaped irregularly oval, spherical or nearly spherical | 5. *D. flahaultii* (p. 174) |
| 7. | Sporangia up to 16 μ broad | 8. *D. versicolor* (p. 175) |
| 7. | Sporangia up to 4 μ broad | 7. *D. parva* (p. 175) |
| 8. | Sporangia up to 10 μ broad, elongate | 6. *D. clavata* (p. 175) |
| 8. | Sporangia 11–6 μ broad, rarely spherical | 8. *D. versicolor* (p. 175) |

### 1. **Dermocarpa hemisphaerica** Setchell et Gardner

in Gardner, New Pacific Coast Mar. Alg., II, Univ. Calif. Publ., Bot., 6: 438, pl. 37, fig. 21, 1918; Setchell and Gardner, the Marine Algae of the Pacific Coast of North America, *ibid.*, 8 (1); 22, pl. 3, fig. 21, 1919; Geitler Kryptogamenflora, 391, fig. 215, 1932.

Pl. 33, Figs. 11, 12

Sporangia single, hemispherical, attached by the flat side, at the base 18–21 μ broad, 10–13 μ high, bright blue-green; wall colorless, moderately thick, not lamellated; endospores up to 20, 0.8–1.2 μ diam., by the successive division of the entire sporangial contents, the first divisions are radial.

On *Cladophora,* in a salt water pond, Krusadi island (Iyengar and Desikachary, 1944, 39); on *Lyngbya* sp. Cape Comorin (Venkataraman, 1957, 472).

Setchell and Gardner and Iyengar and Desikachary describe that in some of their specimens the endospores are liberated by a dissolution of the apex of the sporangium.

The Indian alga is narrower than the Californian one and shows only radial divisions.

### 2. **Dermocarpa leibleiniae** (Reinsch) Born. et Thur.

Notes algologiques, 2: 73, pl. 26, fig. 3–5, 1880; Forti in De Toni, Sylloge Algarum, 5: 130, 1907; Geitler, Kryptogamenflora, 399, fig. 224, 1932 Frémy, Cyano. Cotes d'Eur., 61, pl. 17, fig. 3, 1933.

Pl. 33, Figs. 20, 21

Sporangia elongate, oval, ellipsoidal or pyriform, 8–20 μ broad, single or gregarious, blue or olive-green, or brownish; membrane thick, lamellated; endospores up to 12–20 formed by the successive division of the entire contents of the sporangia or only the upper part of it.

On *Lyngbya majuscula* at Galle, Ceylon (Boergesen, 1936, 59).

#### Var. **pelagica** Wille

Schizophyceae in Hansen, Ergebn. Plankton-Exped., Humboldt-Stift, 4Mf: 50, pl. 1, figs. 1, 2, 1904; Geitler, Kryptogamenflora, 400, fig. 226a, 1932.

Pl. 33, Fig. 15

Cells irregularly pyriform, 18–24 μ broad, 17–24 μ long; endospores 4.5 μ diam.

Indian Ocean (Karsten, 1907, 401).

### 3. **Dermocarpa sphaerica** Setchell et Gardner

in Gardner, New Pacific Coast, Mar. Algae, III, Univ. Calif. Publ., Bot., 6: 457, pl. 39, fig. 14, 1918; Geitler, Kryptogamenflora, 393, fig. 217, 1932; Frémy, Cyano. Cotes d'Eur., 58, pl. 16, fig. 2, 1933.

Sporangia single or gregarious, 8–16 μ diam., pale blue-green, spherical; wall thin, colorless; endospores through the simultaneous division of the contents, 2.5–3 μ diam., liberated through a gelatinisation of the wall.

Type not recorded.

Rao, C. S., (1940, 127) records a form epiphytic on *Pithophora* in a pond, Delhi (Cells up to 16.5-(23.1) μ long). This form differs in having slightly larger sporangia with a thick wall.

### 4. **Dermocarpa olivacea** (Reinsch) Tilden

Minnesota Algae, I, Myxophyceae, 55, pl. 3, figs. 26, 27, 1910; Geitler, Kryptogamenflora, 401, fig. 226b, c, 1932; Frémy, Cyano, Cotes d'Eur., 61, pl. 16, fig. 7, 1933.

Pl. 33, Figs. 13, 14

Plants forming a small or expanded and hemispherical layer; sporangia broad pyriform to spherical, with a marked stalk like elongation at the base, 9.5–17 μ broad, 13–25 μ long; wall thick, lamellated; endospores many, spherical.

On *Lyngbya sordida* at Galle, Ceylon (Boergesen, 1936, 59).

### Var. **gigantea** Rao, C. B.

Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., 3: 167, fig. 1 C, D, 1936.

Pl. 33, Figs. 4, 5

Plants single, broadly club-shaped, contracted at the base to form an elongated stalk; sporangia with pseudovagina 45–56 μ broad and 70–100 μ long, without pseudovagina 20–43 μ broad and 33–76 μ long; faintly stratified; endospores numerous.

On *Cladophora* sp., along with *Stichosiphon indica* (= *S. sansibaricus*) in waste-water drain, Benaras (Rao, C. B., *loc. cit.*).

The variety differs in having much bigger sporangia and in being a freshwater form.

### 5. **Dermocarpa flahaultii** Sauvageau

Alg. recolt. Algerie, Bull. Soc. bot. France, 39: 119, pl. 6, figs. 5, 6, 1892; Forti in De Toni, Sylloge Algarum, 5: 130, 1907; Frémy, Myxo. d'Afr. équat. franc., 65, fig. 69, 1929; Geitler, Kryptogamenflora, 1403, fig. 230, 1932.

Pl. 33, Figs. 18, 19

Plants forming a thin layer, expanding, between other algae; cells oval or spherical, more or less closely arranged, 6–18 μ broad, pale violet.

In the environs of Shembaganur (Frémy, 1942, 21).

### 6. **Dermocarpa clavata** (Setchell et Gardner) Geitler

Kryptogamenflora, 1173, 1932; Schizophyceae, in Engler-Prantl, Natürlichen Pflanzenfam., Ib: 106, 1942.

= *Dermocarpa clavata* Geitler, Kryptogamenflora, 406, fig. 235, 1932.

= *Chamaesiphon clavatus* Setchell and Gardner, Marine Algae of the Revillagigelo islands, Expedition, 1925, Proc. Calif. Acad. Sci., 4th ser., 11: 118, pl. 4, fig. 1, 1930.

Pl. 32, Figs. 1–4

Sporangia single, short club-shaped, mostly straight, seldom slightly bent, 8–10 μ broad at the apex and 20–30 μ (seldom up to 40 μ) long with a distinct short foot, wall thin, colorless; endospores successively formed, seldom the entire contents are utilized, generally only the upper part forms endospores, 6–8–10 endospores, liberation of endospores through the gelatinization of the wall at the apex; color of the protoplast grey blue-green or dirty violet.

On *Lyngbya* and *Rhizoclonium* growing in artificial tank, Madras ( ! ) (Sporangium 6.6–7 μ broad, 19.6–23.5 μ long, endospores eight, 2.6–3 μ broad).

The same species was found epiphytic on *Cladophora* and *Pithophora* in a well in Madras ( ! ) and it differs from the type (endospores 5–18, about 2.6 μ diam.) (Pl. 32, figs. 5, 6).

### 7. **Dermocarpa parva** (Conrad) Geitler

in Pascher's Süsswasserflora, 12: 142, 1925; Frémy, Myxo. Afr. équat. franc., 66, fig. 71, 1929; Geitler, Kryptogamenflora, 403, 1932.

Cells spherical or subspherical, 3–4 μ diam., blue-green; endospores not known.

On *Cladophora* in running soiled trench water, Rangoon, Burma (Skuja, 1949, 23).

Geitler suggests that this may be a juvenile stage of either a *Chamaesiphon* or a *Dermocarpa.*

### 8. **Dermocarpa versicolor** (Borzi) Geitler

Synopt. Darst. Cyano., Beih. bot. Cbl., 41(2): 248, 1925; Frémy Myxo. d'Afr. équat. franc., 66, fig. 70, 1929; Geitler, Kryptogamenflora, 402, fig. 228d, 1932.

Pl. 33, Figs. 16, 17

Sporangia spherical or elongated, 16 µ diam., blue to violet or purple; wall thin with or without a mucilaginous foot; endospores 4–8 seldom up to 16; liberation through the throwing off of a lid-like portion.

On *Lyngbya* growing in a brackish water pool in Krusadai island ( ! ).

The sporangia in the Krusadai material are smaller.—Cells before division 3.9–6.6 µ broad, sporangia 6.6–9.2 µ broad; endospores up to 25, 1.3–2.6 µ in diam.

## STICHOSIPHON Geitler

Kryptogamenflora, 14: 411, 1932.

Sporangia when young ellipsoid or pyriform, attached by means of a mucilaginous foot, sometimes growing elongate, then the contents dividing transversely to form a row of endospores; fully grown sporangia elongate, cylindrical or club shaped with 4–12 or sometimes more endospores lying in a row, liberated by the gelatinisation of the apex of the sporangial wall.

Type species: *Stichosiphon sansibaricus* (Hieron.) Drouet and Daily (= *St. regularis* Geitler).

Geitler (1942) is of the opinion that the two Indian species *St. filamentosa* and *St. indicus* may be identical. *St. indicus* Rao orth. mut. De Toni, J., is a highly variable alga and many forms and varieties have been described under it. It seems to gradually pass into *St. filamentosus.*

Geitler (1942, 108) suggested that *Ch. sansibaricus* Hieron. may be also a *Stichosiphon.* Drouet and Daily (1956, 135) recently confirmed this. They transferred it to *Stichosiphon* and consider all the species of *Stichosiphon* synonymous with it.

One species.

**Stichosiphon sansibaricus** (Hieron.) Drouet et Daily

Butler Univ. Studies, 10: 223, 1952; Rev. Coccoid Myxophyceae, 125, fig. 253, 1956.

= *Chamaesiphon sansibaricus* Hieronymus in Engler, Pflanzenwelt Östafr., C: 8, 1895.

= *Chamaesiphon filamentosa* Ghose, Syst. Ecol. Account of blue-green Algae from Lahore and Simla, J. Linn. Soc. (Lond.) Bot., 46: 337, pl. 31, fig. 1, 1924.

= *Chamaesiphon willei* Gardner, Myxo. Puerto Rico, Mem. N. Y. Bot. Gdn., 7: 34, pl. 7, fig. 62, 1927.

= *Stichosiphon filamentosus* (Ghose) Geitler, Kryptogamenflora, 412, fig. 240, 1932.

= *Stichosiphon indicus* Rao, C. B. orth. mut. De Toni, J. Rao, C. B. A new species of *Stichosiphon* (*S. indica* sp. nov.), Proc. Indian Acad. Sci. B., 2: 535, figs. 1–10, 1935.

= *Stichosiphon indica* var. *tenuis* Gupta, A. B. A contribution to the algal flora of Khajiar, Chamba State, Himachal Pradesh. Proc. nat. Acad. Sci., India, 20(3): 109, figs. 1–3, 1950.

Pl. 32, Figs. 9–13 & Pl. 33, Figs. 8–10

Plants microscopic, blue-green, olivaceous, or rose, solitary, erect, or curved, epiphytic, at first spherical, later cylindrical, 3–7 µ broad, about 400 µ high; contents dividing into a series of spherical, ovoid or cylindrical endospores, endospores generally uniseriate sometimes many seriate; sheath hyaline, thin, somewhat stalked at the base and attached; contents blue-green, olivaceous, violaceous or rose, homogeneous.

On *Pithophora* in a stagnant pool, Bot. Gardens, Lahore in Pakistan (Ghose, 1924, 337 also Randhawa, 1936c, 44); on a species of *Oedogonium* in a stagnant pond, Mandalay, and also in Rangoon (Ghose, 1931, 35; Skuja, 1949, 21) in Burma; On *Cladophora, Enteromorpha, Rhizoclonium, Plectonema, Lyngbya* and *Homoeothrix* growing in stagnant waters, in Benaras (Rao, C. B., 1935, 535; 1936, 167); Ellore, Chittavaram Namdur and Coconada in Andhra State (Rao, C. B., 1938a, 83); Berhampur in Orissa State (Rao, C. B., 1938b, 159); Shembaganur in Madurai dist. (Frémy, 1942, 22) and Madras ( ! ), and McPherson lake, Allahabad (Gupta, 1956, 77; Drouet and Daily, 1956, 136).

## Order PLEUROCAPSALES Geitler

Synopt. Darst. Cyano., Beih. bot. Cbl., 41(2): 238, 1925; incl. Siphononematales, and Endonematales.

Thallus heterotrichous, filamentous or nearly filamentous, but not forming a trichome, devoid of heterocysts or hormogones, multiplication by endospores, formed in sporangia.

### KEY TO THE FAMILIES

1. Thallus not forming filaments or at the most resembling filaments *Pleurocapsaceae* (p. 178)
1. Thallus forming filaments or with a structure which is filament like *Hyellaceae* (p. 179)

## Family PLEUROCAPSACEAE Geitler

Synopt. Darst. Cyano., Beih. bot. Cbl., 41 (2): 238, 1925 *p.p.*

Cells with a firm or gelatinous membrane, sometimes with a differentiation of base and apex, forming colonies which are attached or thallus with a filamentous condition; endospores formed in large cells.

### MYXOSARCINA Printz.

E. Norske Vidensk. Solsk. Skrift, 35; pl. 16, figs. 342–357 (1920), 1921.

Colony rounded, cubical, made of densely packed, nearly cubical or variously pressed cells, division regularly in three directions, generally remaining attached, when old segmented into parts; wall distinct, thin or very thick; endospores present.

Type species: *M. concinna* Printz.

KEY TO THE SPECIES

1. Cells 6–10 μ diam. .................................... 1. *M. spectabilis* (p. 178)
1. Cells 2–3 μ diam. .................................... 2. *M. burmensis* (p. 178)

#### 1. **Myxosarcina spectabilis** Geitler

Arch. Hydrobiol. (u. Planktonk.) 12 (4): 624, 1933; Die Cyanophyceen der deutschen limnologischen Sunda Expedition, ihre Morphologie, Systematik, und Ökologie, Arch. Hydrobiol. (u. Planktonk.), suppl. 14: 387, fig. 14, 1935–36.

Pl. 30, Figs. 1–5 & Pl. 31, Figs. 17–22

Cells in three dimensional colonies, 6.5–10 μ broad; colonial sheath thin, distinct, hyaline, individual sheaths occasionally present, thin, and hyaline; cell-contents blue-green; endospores.

On bricks, Rangoon, in Burma (Skuja, 1949, 21); cement water tubs in laboratory and in cultures of water from Red Hills Lake, Madras ( ! ).

#### 2. **Myxosarcina burmensis** Skuja

Zur Süsswasseralgenflora Burmas, 21, pl. 1, fig. 12, 1949.

Pl. 32, Figs. 20–22

Plants aquatic, minute, microscopic, rounded, sarcinoid; cells more or less, angular or with rounded corners, often arranged in transverse and vertical series, 2–3 μ diam.; pale blue-green or olivaceous, homogeneous, or finely granular; individual sheaths thin, mucilaginous, hyaline; young colonies of 4 cells about 30 μ diam., propagation by the division of the colony into two parts.

Free-floating in circular patches in a glass jar, College laboratory, Rangoon (Skuja, *loc. cit.*).

## Family HYELLACEAE Borzi

Studi sulle Mixoficee, Nuovo Giorn. Bot., ser. 2, 21 : 359, 1914.

Thallus with a filamentous condition without any hormogone formation, with a firm or gelatinous membrane; filaments with one to many rows of cells, with apical growth, unbranched or mostly branched often growing together forming a pseudoparenchymatous structure; branching by the longitudinal division of the apical, dichotomous or tetrachotomous or by the slipping out of an intercalary cell or cells on one side and developing into a lateral branch pseudodichotomous by the slipping out of the penultimate cell and growing forth; thallus made of prostrate region with radially growing filaments forming a discoid thallus and of erect filaments with often endolithic filaments endospores formed in enlarged sporangia.

### KEY TO GENERA

1. Filaments not at all or only a small part perforating or penetrating into the substratum........................................................ 2
1. Filaments totally or for the major part perforating into the calcareous substrata *Hyella* (p. 183)
    2. Thallus when old, more or less hemispherical, formed by radial filaments.. 3
    2. Thallus made of more or less flat crusts with more or less parallel, erect filament *Scopulonema* (p. 179)
3. Thallus with long erect branches, sheath more or less gelatinous and diffluent *Hydrococcus* (p. 180)
3. Thallus with short or few celled erect filaments, envelopes not gelatinizing *Xenococcus* (p. 181)

### **SCOPULONEMA** Ecregovic

Arch. Protistenk., 71: 365, 1930; em. Geitler, in Engler and Prantl, Natürlichen Pflanzenfam., 2 ed., 1b: 91, 1942.

Thallus irregularly expanded, crustaceous, made up of erect and prostrate filaments, prostrate filaments partly endolithic, erect filaments densely packed more or less concrescent along the side, with a firm, thin or thick, or more or less gelatinising walls; cells in one or more rows, unbranched, cells division in two or three directions, daughter cells in groups of 4–8, sometimes filamentous condition lost or obscured and the cells seen in a chroococcaceous condition; sporangia terminal on erect filaments, seldom subterminal or intercalary; endospores 8–32, sometimes more.

Type species: *S. hansgirgianum* Erceg.

### **Scopulonema concharum** (Hansg.) Geitler

Engler and Prantl, Natürlichen Pflanzenfam., 2 ed., 1b: 93, 1942.

= *Pleurocapsa concharum* Hansg., Phys. und Algol. Mittheil., Sitzb. K. Böhm. Ges. wiss., Math. Nat. Cl., 1890 (2): 90, pl. 1, figs. 11–15, 1891; Forti, in De Toni, Sylloge Algarum, 5: 122, 1907.

Thallus small; cells 4–17 μ diam., 1–2 times long, subspherical, oval, ellipsoidal or by compression subangular, filaments irregularly dichotomous, 4–10 cells; walls moderately thin, hyaline; sporangia 12–20 μ, endospores 3–4 μ diam., 8–32 in each sporangium.

On Anadontae shells, Poona (Hansgirg.).

## HYDROCOCCUS Kütz.

Linnaea, 8: 380, 1833; *non* Link

= *Oncobyrsa* Agardh, Flora, 10: 629, 1827; Meneghini, Monogr. Nostoch. ital., Atti R. Acad. Sci. Torino, ser. 2, 5: 95, 1842 (*p.p.*).

Thallus when young, a nematoparenchymatous disc, of a single layer of cells, more or less creeping, later giving rise to erect filaments, erect filaments parallel and generally unbranched, but sometimes dichotomously or trichotomously branched and radially arranged, laterally concrescent and forming a more or less hemispherical expanded lobed thallus; wall thin, in older stages gelatinizing, the cells become loose and form chroococcaceous stage; cells sometimes in groups of 4–8 like Sarcina.

Type species: *Hydrococcus rivularis* Kütz.

The genus *Hydrococcus* Kütz. is preceded by Agardh's genus of the same name based on *O. fluviatilis*. Agardh's alga is considered to be a green tetrasporalen alga (= *Inoderma* Kütz.). Hence Geitler, Harms, and Mattfield (Geitler, 1942), prefer to use the name *Hydrococcus* Kütz. *non* Link and have proposed Kützing's name for conservation, as against Link's. Or the only other alternative is to use *Askenasya* of Möbius. Drouet and Daily (1956) consider Agardh's alga to be a fungus.

### **Hydrococcus rivularis** Kütz.

Linnaea, 8: 380, 1833; Tab. phycologicae, 1: pl. 32, fig. 2, 1846; Species Algarum, 231, 1849.

= *Oncobyrsa rivularis* (Kütz.) Menegh., Monogr. Nostoch. ital., ser. 2, 5: 96, 1843; Forti, in De Toni, Sylloge Algarum, 5: 114, 1907; Frémy, Myxo. d'Afr. équat. franc., 58, fig. 65, 1929; Geitler, Kryptogamenflora, 362, figs. 193–195, 1932; Frémy, Cyano. cotes d'Eur., 41, pl. 9, figs. 1, 2, 1933.

Pl. 30, Figs. 10–14

Thallus made of more or less creeping, nematoparenchymatous, radially arranged filaments, with elongated often curved end cells; later with distinctly radially arranged erect filaments and forming a microscopic hemispherical, lobed, hard thallus up to 2.5 mm diam., blue-green, dark brown or violet; cells (2–) 3–6 μ broad, seldom broader, as long as broad, or somewhat longer with more or less gelatinous, colorless sheath, special envelopes present, cells closely arranged and polygonally adpressed, in the inside more or less isolated rounded blue-green, dirty green, or dirty violet; erect filaments dichotomously or trichotomously branched; often with calcium crystals in the inside of the thallus.

In the environs of Shembaganur (Frémy, 1942, 21).

## XENOCOCCUS Thuret

Essai class. nostoch., Ann. Sci. nat., 6 ser., Bot., 1: 373, 1875; Bornet and Thuret, Notes algologiques, 2: 73, pl. 26, figs. 1, 2, 1880; em. Geitler, Synopt. Darst. Cyano., Beih. bot. Cbl., 41(2): 244, 1925.

Thallus at first blastoparenchymatous and discoid, later forming hemispherical or crustose flakes by the formation of short erect branches or merely loosely arranged cells; erect filaments when present short and few celled, dichotomously or tetrachotomously branched, concrescent laterally forming a blastoparenchymatous thallus; cells in groups of four or eight; sporangia when present in the margins of disc at the tips of erect filaments; endospores many liberated by the rupture or gelatinisation of the sporangial wall.

Type species: *X. schousboei* Thuret.

### KEY TO THE SPECIES

1. Freshwater .................... 1. *X. kerneri* (p. 181)
1. Marine .................... 2
    2. Cells up to 9 μ broad .................... 2. *X. acervatus* (p. 182)
    2. Cells broader .................... 3
3. Cells up to 45 μ broad .................... 3. *X. chaetomorphae* (p. 182)
3. Cells much smaller .................... 4. *X. cladophorae* (p. 183)

### 1. **Xenococcus kerneri** Hansg.

Physiol. algol. Stud., 111, pl. 1, fig. 19, 1887; Forti in De Toni, Sylloge Algarum, 5: 134, 1907; Frémy, Myxo. d'Afr. équat. franc., 61, fig. 67, 1929;

Geitler, Kryptogamenflora, 330, fig. 163, 1932; Frémy, Cyano. cotes d'Eur., 14, pl. 9, fig. 3, 1933.

Pl. 31, Figs. 23–25, 27

Colonies at first single layered, discoid and blastoparenchymatous, later orming a parenchymatous thallus by the lateral approximation of the vertical ranches; erect filaments 6–10 celled, dichotomous or tetrachotomously ranched; cells in groups of 4 or 8; membrane thick, lamellated or unlamellated, t the margins of the thallus with a diffluent or gelatinising envelope, which is olorless or seldom yellowish; cells 3.5–6 μ broad, up to 10 μ long; sporangia narginal terminal on the erect filaments; endospores 32, successively formed, nore or less 3 μ broad.

On *Lyngbya majuscula* in a slow moving stream near Tirupati ( ! ).

Drouet (Field Mus. nat. Hist., Bot., 20(6) : 125, 1942) transfers this species ogether with *X. acervatus* Setchell and Gardner to *Pleurocapsa* on account of the elatinous nature of the wall.

2. **Xenococcus acervatus** Setchell et Gardner

in Gardner, New Pacific Coast Algae, III, Univ. Calif. Publ. Bot., 6: 59, pl. 39, fig. 13, 1918: Geitler, Kryptogamenflora, 33, fig. 168, 1932.

Pl. 31, Fig. 28

Plants epiphytic, division in two directions; colony at first one layered, ells later growing one over the other, at first angular soon becoming spherical, yriform or adpressed, 3–6 μ broad, wall thin; contents pale blue-green omogeneous; endospores not known.

On *Lyngbya sordida* and *L. majauscula,* Galle, in Ceylon. (Boergesen, 936, 59).

3. **Xenococcus chaetomorphae** Setchell et Gardner

In Gardner, New Pacific Coast Marine Algae, III, Univ. Calif. Publ., Bot., 6: 436, pl. 36, figs. 2–4, 1918; Geitler, Kryptogamenflora, 336, fig. 173, 932.

Pl. 31, Fig. 25

Cells differently arranged and of varying shape and size, spherical r angular, or often very elongated and blue-green, up to 45 μ long and up to 25 μ high, bright blue-green; sporangia similar to vegetative cells in shape; ndospores formed through successive divisions of the whole protoplast, 1.3–2.6 μ diam.

On *Chaetomorpha litorea* floating in masses in the estuarine region of river Cooum, Madras (Iyengar and Desikachary, 1944, 29).

4. **Xenococcus cladophorae** (Tilden) Setchell et Gardner

in Gardner, New Pacific Coast Marine Algae, III, Univ. Calif. Publ. Bot., 6: 461, pl. 38, fig. 8, 1918; Geitler, Kryptogamenflora, 336, fig. 171, 1932.

Pl. 31, Fig. 26

Cells irregularly arranged in a single layer, spherical, angular or pyriform, 8–15 μ diam., sometimes up to 22 μ, blue-green; wall colorless, often gelatinising; sporangia similar to the vegetative cell; endospores formed by successive divisions 1.5–2(–2.6) μ diam.

On *Cladophora* sp., in a saltwater pond inside the Krusadi island (Iyengar and Desikachary, 1944, 39).

### **HYELLA** Born. et Flah.

Note sur deux nouveaux genres d'Algues perforantes, J. Bot., Paris, 2: 163, 1888.

Thallus filament-like, growing on calcareous stones, shells, molluscs or corals, made of a lower expanding many seriate, creeping filaments and very short erect filament, free or laterally concrescent forming a nematoparenchymatous thallus; pseudoparenchymatously or laterally branched; filaments generally with a thick often lamellated gelatinous wall; perforating portion with cells in a single row, rhizoid like in appearance, cells very long, pseudodichotomous, dichotomous or laterally branching; sporangia in upper parts of the thallus terminal or intercalary; endospores many formed by successive divisions; often in chroococcaleen condition; nannocytes present.

Type species: *H. caespitosa* Born. and Flah.

**Hyella caespitosa** Born. et Flah.

Note sur deux noveaux genres d'Algues perforantes, J. Bot., Paris, 2: 163, 1888; Sur quelques plantes vivantes test dans le Calcaire des Mollusques, Bull. Soc. bot. France, 36: 146, pl. 10, figs. 7, 8, pl. 11, figs. 1–10, 1889; Forti in Sylloge Algarum, 5: 125, 1907; Geitler, Kryptogamenflora, 369, fig. 198, 1932; Frémy, Cyano. cotes d'Eur., 49, pl. 12, figs. 4–10, pl. 13, 1933.

Plate 34

Thallus at first punctate or in flakes or cushion shaped. 1–2 mm., later coalescing to form a yellowish green or yellow-brown thallus, often gelatinous, primary filaments on the upper surface prostrate bent or curved, with cells in one row or in many rows forming a chroococcaleen stage; perforating filaments elongate, single rowed, filaments up to 100–200 μ long, cells 4–10 μ broad, end cells up to 60 μ long, yellow-green or blue-green; wall mostly

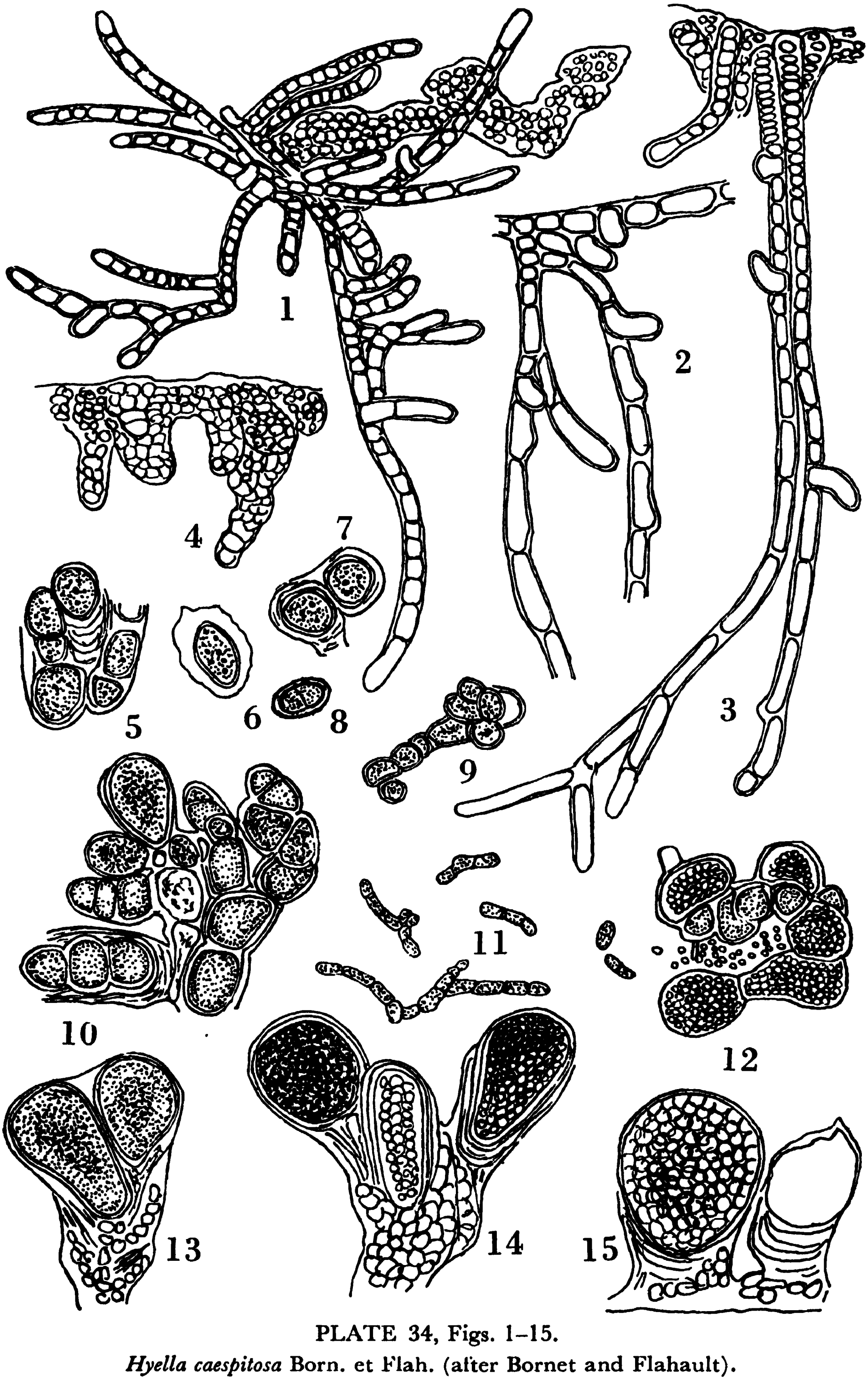

PLATE 34, Figs. 1–15.
*Hyella caespitosa* Born. et Flah. (after Bornet and Flahault).

thick in the upper part, often lamellated, sometimes gelatinous, colorless; sporangia intercalary or terminal, generally very prominently enlarged pyriform, with thickened wall; endospores many formed by successive division.

Mahabalipuram (Srinivasan, 1946) and on shells all round the peninsular Coast ( ! ).

## Order NOSTOCALES Geitler

Synopt. darst. Cyano., Beih. bot. Cbl., 41 (3): 252, 1925.

Plants filamentous, with filament and trichome organization, hormogones present; heterocysts, akinetes, endospores, hormocysts present; true branching absent, false branching present.

The filamentous forms include both branched and unbranched forms. The branching is of two types, false branching and true branching (for a detailed account of the different types of branching see pp. 32-37).

Based on branching the hormogonales fall into two homogeneous orders, Nostocales and the Stigonematales (Geitler, 1925; see also Geitler, 1932, 1942; Fritsch, 1942, 1944, 1945).

The presence or absence of heterocysts have been used as criteria for the division of the Hormogonales into Homocysteae (Homocystineae of Setchell and Gardner, 1919; Aheterocysteae of Elenkin and Oscillatoriales of Copeland, 1936 *non* Elenkin, *non* Borzi) and Heterocysteae (Bornet and Flahault, 1886, 1888; Gomont, 1892). This is not accepted by some phycologists. Such a division is very artificial and separate many genera which have otherwise very great affinities. Elenkin (1936) separates all the homocystous forms into the Oscillatoriales and divides them into a number of families parallel to the ones contained in the Heterocysteae.

While most families of the group are distinct some are not so distinct that it sometimes seems whether it is not worthwhile to unite them all into one family owing to presence of intermediate characters between the families for eg. Nostochopsidaceae, Mastigocladaceae, Mastigocladopsidaceae, and the Stigonemataceae. It may be remembered that Borzi (1914-1919) includes all the genera of these families in one family and he divides the same, Stigonemataceae, into a number of subfamilies. But this can be done only after more is known of the interrelationships and variations of the different genera.

### KEY TO THE FAMILIES

1. Trichomes without false branching or with incipient false branching ........... 2
1. Trichomes commonly false branched ........................................ 4
    2. Without heterocysts spores commonly absent .... *Oscillatoriaceae* (p. 186)
    2. With heterocysts and spores........................................ 3

3. Trichomes differentiated into base and apex ............ *Microchaetaceae* (p. 507)
3. Trichomes not so differentiated ............................ *Nostocaceae* (p. 349)
  4. Without an intercalary meristematic zone and generally without a terminal hair *Scytonemataceae* (p. 434)
  4. With an intercalary meristematic zone and a terminal hair *Rivulariaceae* (p. 516)

## Family OSCILLATORIACEAE Kirchner

Schizophyceae in Engler and Prantl, Nat. Pflanzenfam., I Ed., 1a, p. 61, 1898; *non sensu* Elenkin 1936.

Trichome with a single row of similar and uniformly broad cells, only sometimes tapering at the extreme ends, not forming a hair, not branched, without or with diffluent mucilage or a homogeneous or more or less lamellated firm sheath; generally unbranched but occasionally branched in genera with a firm sheath; growth intercalary in some apical; trichome straight or regularly or irregularly spirally coiled; heterocysts and spores absent; hormogones present, many showing a spiral movement by rotation along the longitudinal axis.

### KEY TO GENERA

1. Trichomes cylindrical .............................................. 2
1. Trichomes flattened ................................ *Crinalium* (p. 246)
  2. Trichomes typically many in a sheath; sheath at the apex generally closing after hormogone formation ............................ 3
  2. Trichomes without a sheath or single within a sheath; end sheaths open always ............................................ 9
3. Trichomes very many in a sheath, densely arranged ...................... 4
3. Trichomes fewer, loosely arranged........................................ 5
  4. Sheath more or less slimy; filaments twisted into rope-like bundles *Microcoleus* (p. 341)
  4. Sheath more or less firm; filaments not twisted; thallus tufted *Sirocoleus* (p. 340)
5. Filaments unbranched ............................ *Polychlamydum* (p. 249)
5. Filaments branched .................................................. 6
  6. Sheath very soft, thick, more or less diffluent, trichomes fewer in each sheath ............................................ *Dasygloea* (p. 250)
  6. Sheath and trichome otherwise ........................................ 7
7. Sheath slimy, end cell with a calyptra ...................... *Hydrocoleum* (p. 346)
7. Sheath more or less firm, end cell without a calyptra.......................... 8
  8. Many trichomes in a sheath; filaments richly branched *Schizothrix* (p. 321)
  8. Fewer or only one trichome in each sheath; sparingly branched *Porphyrosiphon* (p. 248)
9. Trichome with a prominent sheath ........................................ 10
9. Trichome without a sheath .............................................. 12
  10. Sheath firm .......................................................... 11
  10. Sheath mucilaginous .................................................. 15

11. Filaments not in bundles .................................. *Lyngbya* (p. 278)
11. Filaments mostly in erect bundles .......................... *Symploca* (p. 334)
  12. Trichome more or less straight, not regularly spirally coiled ............ 13
  12. Trichome regularly spirally coiled ...................................... 14
13. In free swimming bundles ................................ *Trichodesmium* (p. 243)
13. Not in bundles ............................................ *Oscillatoria* (p. 198)
  14. Cells of trichome not visible or unicellular ............. *Spirulina* (p. 192)
  14. Cells of trichome clearly visible......................... *Arthrospira* (p. 187)
15. Filaments single ........................................... *Katagnymene* (p. 247)
15. Filaments forming a thallus with more or less confluent sheaths *Phormidium* (p. 250)

## ARTHROSPIRA Stizenberger

*Spirulina* and *Arthrospira,* Hedwigia, 1 : 32, 1852; Gomont, Monogr. Oscill., 246, 1892.

Trichomes multicellular, cylindrical, without sheath, loosely and regularly coiled, usually of relatively large diameter and large spirals, with comparatively short and fewer coils; cross-walls distinct, apices slightly or not all tapering, terminal cell rounded, calyptra absent.

Type species: *A. jenneri* (Hass.) Stizenb.

The separation of this genus is one of practical advantage. Microscopically it seems to be easy to identify the multicellular septate forms from the (apparently ?) aseptate forms. Opinions have variously ranged themselves for and against this step. Gomont (1892) first recognised *Arthrospira.* Many others have pointed out that many aseptate forms are only apparently so and have revealed septa after proper chemical treatment and staining (Gardner, N. L., Univ. Calif. Publ. Bot., 6: 377–379, 1917; Schmid, G., Ber. dtsch. bot. Ges., 38: 368–371, 1920; Arch. Protistenk., 43: 463–6, 1921; Zuelzer, M. Arch. Protistenk., 24: 1–59, 1911; Dobell, C. E., Arch. Protistenk., 26: 117–240, 1912; Fagini, G. P., Nuova Notarisia, 31–49, 1925). Geitler (1925, 1932, 1942) has followed these conclusions and recognises only a single genus *Spirulina.* He, however, splits the genus into two sub-sections, *Arthrospira* (Stizenb.) Geitler and *Euspirulina* Forti. Setchell and Gardner (1919), notwithstanding, have separated *Arthrospira* from *Spirulina* as a matter of convenience. Crow (Trans. Amer. micr. Soc., 46: 139–148, 1927) studied in great detail a number of species of *Spirulina* and *Arthrospira* and found that there are unseptate forms (eg., *S. princeps* West). Based on these studies he suggested the delimitation of the *Arthrospira* to septate forms. His observations are yet to be confirmed (see also Fritsch, 1945, 832). Yet for the present it will be convenient to retain these two genera separate as has been done by Fritsch (1945), Drouet (1951) and others.

Elenkin (1925) first placed *Spirulina* in Chroococcaceae as a unicellular form but he later (1936, 1949) restored it back to the Oscillatoriaceae.

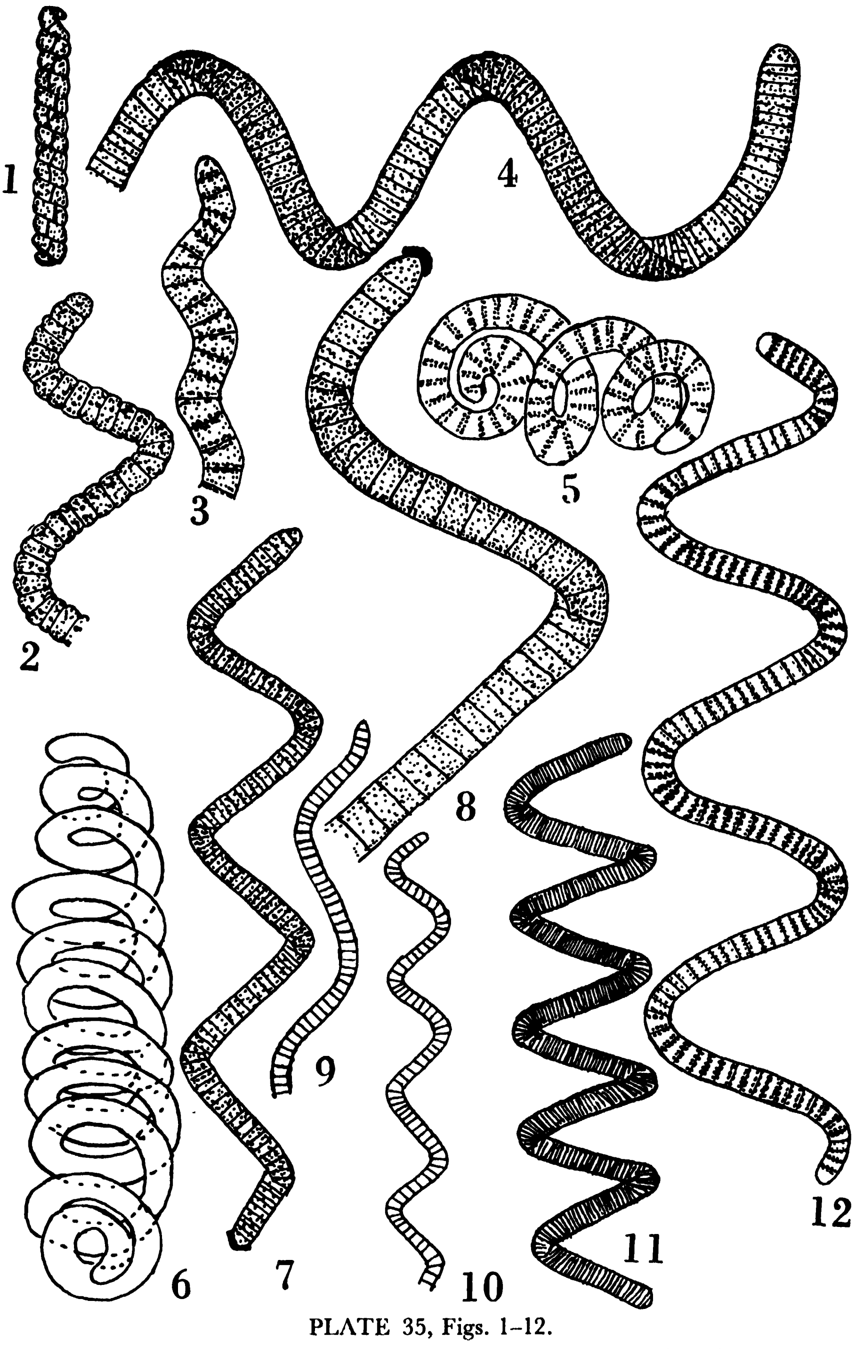

PLATE 35, Figs. 1–12.

1. *Arthrospira spirulinoides* Ghose (after Ghose); 2. *A. platensis* (Nordst.) Gomont (after Gomont); 3. *A. jenneri* Stizb. (after Gomont); 4, 11. *A. platensis* v. *tenuis* (Rao) comb. nov. (after Rao, C. B.); 5, 6. *A. platensis* f. *granulata* f. nov. (orig.); 7, 8. *A. massartii* v. *indica* var. nov. (orig.); 9. *A. massartii* Kuff. (Kuff.); 10. *A. massartii* f. (after Skuja); 12. *A. khannae* Drouet and Strickland (after Drouet and Strickland).

## KEY TO THE SPECIES

1. Spirals very close, touching each other .................. 1. *A. spirulinoides* (p. 189)
1. Spirals away from one another .................. 2
    2. Spirals less than 20 μ broad .................. 5
    2. Spirals more than 20 μ broad .................. 3
3. Spirals about 20 μ broad .................. 2. *A. khannae* (p. 189)
3. Spirals broader .................. 4
    4. Trichome 6–8 μ broad .................. 3. *A. platensis* (p. 190)
    4. Trichome 5 μ broad .................. 4. *A. massartii* (p. 191)
    4. Trichome 2 μ broad .................. 5. *A. tenuis* (p. 191)
5. Spirals up to 6 μ broad .................. 6. *A. gomontiana* (p. 192)
5. Spirals up to 9–16 μ broad .................. 7. *A. jenneri* (p. 192)

### 1. **Arthrospira spirulinoides** Ghose

A systematic and ecological account of a collection of Blue-green Algae from Lahore and Simla, J. Linn. Soc. Bot., 56: 338, pl. 31, fig. 4, 1923.

= *Spirulina spirulinoides* (Ghose) Geitler, in Pascher's Süsswasserflora, 12: 344, 1925; Kryptogamenflora, 921, fig. 590a, 1932.

Pl. 35, Fig. 1

Trichome blue-green, straight or somewhat bent, up to 60 μ long, not constricted at the cross-walls; cells 5–6 μ broad, 4–12 μ long, distance between spirals 12–15 μ.

In standing rain waters, Lahore in Pakistan (Ghose, *loc. cit.*).

### f. **tenuis** (Singh, R. N.) comb. nov.

= *Sp. spirulinoides* f. *tenuis* Singh, R. N. An investigation into the algal flora of paddy-field soils of the United Provinces, Indian J. agric. Sci., 9: 67, 1939b.

Trichome 2–3.3 μ broad, cells 8–11 μ long, spirals 6–7 μ broad, and 12–14 μ distant from each other.

On moist soil, paddy-field, Gorakhpur (Singh, R. N.).

This form differs in the narrower trichomes.

### 2. **Arthrospira khannae** Drouet et Strickland

in Drouet, F. Studies in Myxophyceae I, Field, Mus. nat. Hist., Bot., 20(6); 141, pl. 1, fig. 6, 1942.

Pl. 35, Fig. 12

Trichomes planktonic, blue-green, forming loose spirals, spirals about 20 μ broad, not constricted at the cross-walls, ends slightly attenuated and subcapitate, 3–5 μ broad, spirals about 20 μ distant; cells short, 1/3 as long as broad, cross-walls granulated; cells contents with large gas-vacuoles.

Planktonic in a pond, Rangoon, Burma (Drouet, *loc. cit.*).

### 3. **Arthrospira platensis** (Nordst.) Gomont

Monogr. Oscillariées, 247, pl. 7, fig. 27, 1892.

= *Spirulina platensis* (Nordst.) Geitler, in Pascher's Süsswasserflora, 12: 344, 1925; Frémy, Myxo. d'Afr. équat. franc., 232, fig. 205, 1929; Geitler, Kryptogamenflora, 925, fig. 590d, 589, 1932.

Pl. 35, Fig. 2

Thallus blue-green; trichomes slightly constricted at the cross-walls, 6–8 μ broad, not attenuated at the ends or only a little attenuated, more or less regularly spirally coiled; spirals 26–36 μ broad, distances between the spirals 43–57 μ; cells nearly as long as broad, or shorter than broad, 2–6 μ long, cross-walls granulated; end-cells broadly rounded.

In stagnant waters, Lahore in Pakistan (Ghose, 1924, 333; Randhawa, 1936C, 40); Calcutta in Bengal (Biswas, 1927, 51; 1942, 199); in plankton in Beira lake, Ceylon (Holsinger, 1954, p. 9).

*Arthrospira platensis* is a highly variable species. The regularity of the spirals, the distance between the spirals and also the apparent visibility of the cross-walls are all variable features and these have been well described by Rich (Rev. algol., 6: 75–9, 1931).

#### f. **granulata** forma nov.

Pl. 35, Figs. 5, 6

Trichome light blue-green, not constricted at the cross-walls, 6.6–7.9 μ broad, slightly less broad at the ends, spirally coiled, spirals at the ends being narrower than the middle, spirals 19.3–35.4 μ and (16.1–)20.5–44.9 μ distant; cells discoid, cross-walls often indistinct sometimes distinct, granulated.

In a pool at Coconada.

#### Var. **tenuis** (Rao, C. B.) comb. nov.

= *Spirulina platensis* var. *tenuis* Rao, C. B., The Myxophyceae of the United Provinces, Proc. Indian Acad. Sci. B., 6: 365, fig. 7A, 1937.

Pl. 35, Figs. 4, 11

Plant mass greyish brown; trichomes pale blue-green, of uniform width, 5.1–6.4 μ broad, in regular spirals, spirals 30–34 μ broad and 40–52 μ distant, not constricted at the joints; cells disc-shaped; end-cells with rounded apices.

In waste-water drain and in a pond, Benaras (Rao, C. B., 1937b, 365).

This alga has been reported from Dharbanga, Bihar, free-floating in a tank (Rao, C. S., 1939, 148). This alga differs from the Benaras alga in having trichomes (4–6 μ) with larger cells, and broader spirals (spirals 30–43 μ broad, and 40–55 μ distant).

Var. **non-constricta** (Banerji) comb. nov.

Pl. 36, Figs. 1, 2

= *Spirulina platensis* var. *non-constricta* Banerji, J. Dept. Sci., Calcutta Univ., n.s., 1: 100, 1938.

Trichomes 4–8 μ broad, unconstricted, cells 2–3.5 μ long, spirals 20–50 μ broad and 40–62 μ distant.

Forming a water-bloom in a Dhapa near Salt lakes, Calcutta (Banerji, 1938, 100).

### 4. **Arthrospira massartii** Kuffareth

Contribution a l'étude Flore Algologique du Luxembourg meridional, II, Ann. biol. lacustre, 7: 264, fig. 16, 1914.

= *Spirulina massartii* (Kuff.) Geitler in Pascher's Süsswasserflora, 12: 346, 1925; Kryptogamenflora, 925, fig. 590b, 1932.

Pl. 35, Figs. 9, 10

Trichomes loosely coiled, spirals 28 broad, distance between spirals (60–) 90 μ, cells 5(–6) μ broad, 2–4 μ long, greyish blue-green; end-cells rounded conical, cross-walls not granulated, no gas-vacuoles.

Type not recorded.

Var. **indica** var. nov.

Pl. 35, Figs. 7, 8

Trichomes loosely coiled, 3.9–5.2 μ broad, not constricted at the cross-walls, apex of trichome often with a calyptra, spirals 32.9–41.9 μ broad and spirals 38.6–51.5(–60) μ; cells 1/3–1/4 as long as broad, cross-walls not granulated.

In ponds and beach pools, Madras ( ? ).

### 5. **Arthrospira tenuis** Bruhl et Biswas

Algae of Bengal Filter Beds, J. Dept. Sci., Calcutta Univ., 4: 7, 1922a.

= *Spirulina tenuis* (Bruhl and Biswas) Geitler, in Pascher's Süsswasserflora, 12: 449, 1925; Kryptogamenflora, 926, 1932.

Trichome single, pale blue-green, seemingly loosely coiled, mostly with 4 spirals, spirals 20–35 μ broad, lightly constricted at the cross-walls, cross-walls indistinct, trichome 2 μ broad, cells 2–3 μ long, nearly quadratic.

Filterbeds, Faridpur in Bengal (Bruhl and Biswas, *loc. cit.*); in the temporary microphytoplankton of the River Hooghly (Biswas, 1942, 198).

### 6. **Arthrospira gomontiana** Setchell

Bull. Torrey bot. Cl., 22: 430, 1895.

= *Spirulina gomontiana* (Setchell) Geitler, in Pascher's Süsswasserflora, 12: 344, 1925; Kryptogamenflora, 924, 1932.

Free-swimming, trichome 2.5–3 μ broad, attenuated at the apices, regularly spirally coiled, spirals 6 μ broad and 16–18 μ distant; cells 4–5 μ long; pale blue-green, cross-wall commonly granulated.

Type not recorded.

Gupta (1956, p. 78) described v. *crassa* (Gupta) comb. n. (= *Sp. gomontiana* var. *crassa*).—Trichome 4–4.5 μ broad, cells 1.5–3 μ long, spirals 8 μ broad and 13.4–15 μ distant.

### 7. **Arthrospira jenneri** Stizenb. ex Gomont

Stizenberger, *Spirulina* and *Arthrospira,* Hedwigia, 1: 32, 1852; Gomont, Monogr. Oscillariées, 247, pl. 7, fig. 26, 1892.

= *Spirulina jenneri* (Stizenb.) Geitler, in Pascher's Süsswasserflora, 12: 344, 1925; Kryptogamenflora, 924, fig. 590c, 1932.

Pl. 35, Fig. 3

Thallus blue-green; trichomes blue-green, unconstricted at the cross-walls or only very little constricted, 5–8 μ broad, not attenuated at the ends, more or less regularly spirally coiled, spirals 9–15 μ broad, distance between two spirals 21–31 μ; cells nearly as long as broad, or somewhat shorter than broad, 4–5 long, the cross-walls granulated; end-cells broadly rounded.

In stagnant ponds, Lahore in Pakistan (Ghose, 1919, 10), Rangoon in Burma (Skuja, 1949; 44).

In the Lahore alga the trichome is 4–6 μ broad, the spirals 10–16 μ broad and the spirals are 8 μ distant. In the Burmese specimens the spirals are 9–10 μ broad and 19–21 μ distant.

## **SPIRULINA** Turpin em. Gardner

Turpin in Dic. Sci. nat. de Levrault, 50: 309, 1827; em. Gardner, New Pacific Coast Marine Algae I, Univ. Calif. Publ. Bot., 6: 379, 1917; Gomont Monogr. Oscillariées, 249, 1892.

Trichomes unicellular or multicellular cylindrical, sheath absent; loosely or tightly coiled into a more or less regular spiral; apex of trichome usually not attenuated; cross-walls if present obscured; terminal cell rounded, without calyptra.

Lectotype: S. *major*, Kütz. ex Gomont 1892, p. 251.

Turpin's genus was based on *Spirulina oscillarioides*. This species has been placed under *spicies inquirendae* by Gomont.

## KEY TO THE SPECIES

1. Spirals distant .................................................. 3
1. Spirals close to each other .................................................. 2
    2. Spirals broader than 3 μ ........................ 1. *Sp. subsalsa* (p. 193)
    2. Spirals 2–2.7 μ broad ...................... 2. *Sp. labyrinthiformis* (p. 195)
3. Spirals irregular .................................. 3. *Sp. meneghiniana* (p. 195)
3. Spirals regular .................................................. 4
    4. Trichomes less than 2 μ broad .................................. 5
    4. Trichomes broader than 2 μ broad .................................. 7
5. Spirals loose, 17–22 μ distant .......................... 4. *Sp. laxissima* (p. 196)
5. Spirals closer .................................................. 6
    6. Spirals 1.25–2 μ away from each other, trichomes 0.6–0.9 μ broad 5. *Sp. subtilissima* (p. 196)
    6. Spirals farther away, trichomes 1.2–1.7 μ broad ....... 6. *Sp. major* (p. 196)
7. Trichomes 4.5–5 μ broad .............................. 7. *Sp. princeps* (p. 197)
7. Trichomes narrower .............................. 8. *Sp. gigantea* (p. 197)

### 1. **Spirulina subsalsa** Oerst. ex Gomont

Oersted., Beretn. Exc. til Trindelen etc., Nat. Tidskr., 17, pl. 7, fig. 4, 1842; Gomont, Monogr. Oscillariées, 253, pl. 7, fig. 32, 1892; Forti in De Toni, Sylloge Algarum, 5: 214, 1907; Frémy, Myxo. d'Afr. équat. franc., 236, fig. 211, 1930; Geitler, Kryptogamenflora, 927, fig. 593a, 1932; Frémy, Cyano. cotes d'Eur., 133, pl. 31, fig. 24, 1933.

= *Sp. turfosa* Cramer, Hedwigia, 2: bl, pl. 12, fig. 1, 1863.

= *Sp. tenuissima* Kütz., Alg. Aq. dulc., 14, no. 131, 1836; Phyc. gene., 183, 1843; Phyc. germ., 156, 1845; Tab. Phycologicae, 1: 26, pl. 37, fig. 4, 1845. *non* Nordst.

Pl. 36, Figs. 3, 9

Trichomes 1–2 μ broad, blue-green to reddish violet, mostly somewhat irregularly densely spirally coiled, rarely regularly coiled, sometimes loosely coiled, forming a bright blue-green or yellowish-green thallus, or single among other algae, spirals very close to each other, 3–5 μ broad.

Among other algae or on dead leaves in stagnant waters, Calcutta in Bengal (Turner, 1892, 12; Banerji, 1938, 100), Hyderabad (Ghousuddin,

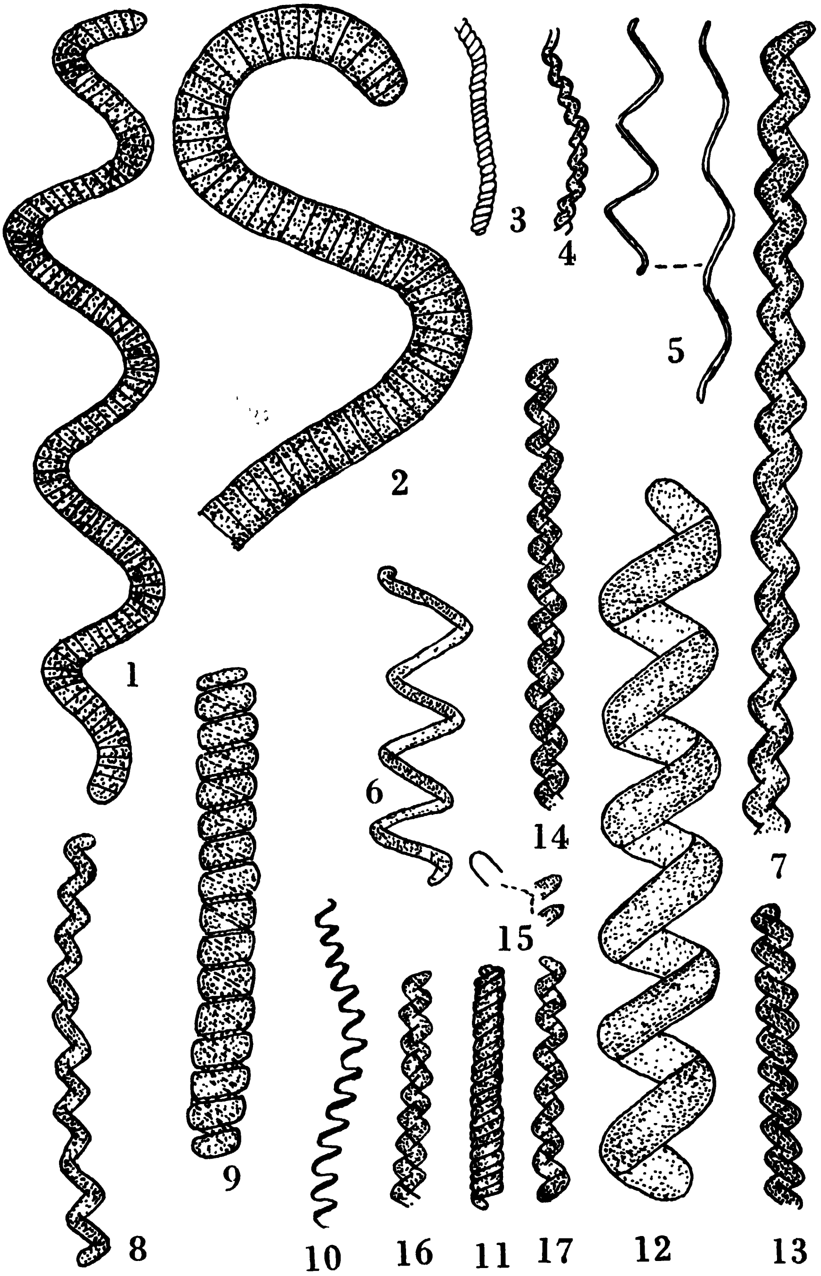

PLATE 36, Figs. 1–17.

1, 2. *Arthrospira platensis* v. *non-constricta* (Banerji) comb. nov. (after Banerji); 3, 9. *Spirulina subsalsa* Oerstd. (3 after Gomont. 9 orig.); 4, 8. *S. meneghiniana* Zanard. (4 after Gomont, 8 orig.); 5. *S. laxissima* West, G. S. (after West); 6. *S. laxissima* forma *major* f. n. (orig.); 7. *S. princeps* West & West (orig.); 10. *S. subtilissima* (Kütz.) (after Frémy); 11. *S. labyrinthiformis* (Menegh.) Gom. (after Frémy); 12, 14–17. *S. gigantea* Schmidle (12 after Frémy; 14–17 after Skuja); 13. *S. major* Kütz. (after Skuja).

1936, 148), Palacol and Polamur in Andhra (Rao, C. B., 1938a, 89), Berhampur in Orissa (Rao, C. B., 1938b, 163), Fatahil, Barpathar and Sibsagar in Assam (Parukutty, 1939, 233) and Delhi (Rao, C. S., 1940, 128), in hot springs, Vajreshwari near Bombay (Gonzalves, 1947, 25) and on seashore near Colaba in Bombay (Dixit, 1936, 102), Tirupati ( ! ), in salt pans, Pakala ( ! ) and o wet soil, Madras ( ! ) in India; Rangoon in Burma (Skuja, 1948, 44), and brackish water ponds in Ceylon (Crow, 1923b, 141).

Large variation in the dimensions of the trichome has been reported. Breadth of trichome 0.8 μ (Dixit, 1936, 102) and 2 μ (Skuja, 1949); Diam. of spirals 1.7 (Dixit) and 3.5–4 μ (Skuja). Parukutty (1939) describes the distance between the spirals 3–5 μ.

### 2. **Spirulina labyrinthiformis** (Menegh.) Gomont

Monogr. Oscillariées, 255, 1892; Forti in De Toni, Sylloge Algarum, 5: 215, 1907; Frémy, Myxo. d'Afr. équat. franc., 237, fig. 212, 1929; Geitler, Kryptogamenflora, 928, 1932; Frémy, Cyano, cotes d'Eur., 134, pl. 31, fig. 25, 1933.

Pl. 36, Fig. 11 & Pl. 49, Fig. 1

Trichome 1 μ broad, green, very regularly coiled forming a dirty, dark-green thallus; spirals close to each other, spirals 2–2.7 μ broad.

In backwaters, Ennore near Madras, and on shells amidst other algae, Krusadai Island (Iyengar and Desikachary, 1944, 54), in a pond, Mandalay in Burma (Skuja, 1948, 44).

In the Krusadai island material the spirals were up to 3 μ broad.

### 3. **Spirulina meneghiniana** Zanard. ex Gomont

Zanardini, Not. intorno alle Cellul. marine ed elittor. di Venezia, Atti. R. Inst. Veneto, 6: 80, 1847; Gomont, Monogr. Oscillariées, 250, pl. 7, fig. 28, 1892; Forti in De Toni, Sylloge Algarum, 5: 209, 1907; Geitler, Kryptogamenflora, 928, fig. 593d, 1932; Frémy, Cyano. cotes d'Eur., 131, pl. 31, fig. 17, 1933.

Pl. 36, Fig. 8

Trichome 1.2–1.8 μ broad, flexible, irregularly spirally coiled, bright blue-green, forming a thick blue-green thallus; spirals 3.2–5 μ broad and 3–5 μ distant from each other.

Planktonic in a pond, Ballygunge, Calcutta (Banerji, 1938, 101) and in a beach pool, Madras ( ! ).

The Madras plant was 1.3–2 μ broad and its spirals 2.6–3.9 μ broad and 2.6–3.9 μ distant from each other.

### 4. **Spirulina laxissima** West, G. S.

J. Linn. Soc. (Lond.) Bot., 38, 78, pl. 9, fig. 6, 1907; Frémy, Myxo. d'Afr. équat. franc., 234, fig. 207, 1929; Geitler, Kryptogamenflora, 929, 1932.

Pl. 36, Fig. 5

Trichome 0.7–0.8 μ broad, blue-green, spirals very loose, but regular, 4.5–5.3 μ broad; 17–22 μ distant from each other, end-cells rounded, obtuse.

Freshwater algae, India (Hansgirg, see De Toni, 1907, 210) and slow sandfilters in Madras (Ganapathi, 1940a, 246).

### forma **major** f. nov.

Pl. 36, Fig. 6

Trichome 1.3 μ broad, spirals not close, about 6.6 μ broad and 5.2–6.5 μ distant from each other.

Rainwater pool, Pudukkotah, Madras State (!).

### 5. **Spirulina subtilissima** Kütz. ex Gomont

Kützing, Phyc. gene., 183, 1843; Gomont, Monogr. Oscillariées, 252, pl. 7, fig. 30, 1892; Forti, in De Toni, Sylloge Algarum, 5: 212, 1907; Frémy, Myxo. d'Afr. équat. franc., 233, fig. 206, 1930; Geitler, Kryptogamenflora, 929, 1932.

Pl. 36, Fig. 10

Trichome 0.6–0.9 μ broad, regularly spirally coiled, bright blue-green or yellowish, spirals 1.5–2.5(–2.8) μ broad, distance between the spirals 1.25–2 μ.

In stagnant waters along with other algae. — Calcutta (Banerji, 1938, 101), Shembaganur near Madurai (Frémy, 1942, 21), Bandra near Bombay (Gonzalves and Joshi, 1946, 176) and on *Neomeris annulata* from Pamban (Iyengar and Desikachary, 1944, 56).

### 6. **Spirulina major** Kütz. ex Gomont

Kützing, Phyc. gene., 183, 1843; Gomont, Monogr. Oscillariées, 251, pl. 7, fig. 29, 1892; Forti, in De Toni, Sylloge Algarum, 5; 210, 1907; Frémy, Myxo. d'Afr. équat. franc., 234, fig. 208, 1929; Geitler, Kryptogamenflora, 930, fig. 595, 1932.

Pl. 36, Fig. 13

Trichome 1.2–1.7(–2) μ broad, regularly spirally coiled, blue-green, spirals 2.5–4 μ broad and 2.7–5 μ distant.

On moist soil or among other algae in salt lakes, or other stagnant or flowing waters.—Rangoon (Ghose, 1925, 246; 1927, 79), Loktak lake (Bruhl and Biswas, 1926, 265), Cherrapunji (Biswas, 1934, 11), Fatehil, Barpathar and Sibsagar (Parukutty, 1939, 233) in Assam; Calcutta (Biswas, 1926, 22; 1942, 199; Banerji, 1938, 101), Malnad (Dixit, 1936, 103) and Bandra (Gonzalves and Joshi, 1946, 176) in Bombay State, Hyderabad (Ghousuddin, 1936, 149), Ellore, Narsapur, Polamur and Mogalthur in Andhra (Rao, C. B., 1938a, 89), Benaras (Rao, C. B., 1937b, 365) and Allahabad (Gupta, 1956, 78) in U.P., and Veli in Travancore (Parukutty, 1940, 119).

While the majority of the Indian forms recorded above are in close agreement with the type, yet a few variations are noticeable in the distance between the spirals (2.4–6.6 μ).

### 7. **Spirulina princeps** W. et G. S. West

A contribution to the freshwater algae of Ceylon, Trans. Linn. Soc. (Lond.) Bot., 2 ser., 6: 205, 1902; Forti, in De Toni, Sylloge Algarum, 5: 211, 1907; Frémy, Myxo. d'Afr. équat. franc., 236, fig. 210, 1929; Geitler, Kryptogamenflora, 931, fig. 593d, 1932.

Pl. 36, Fig. 7

Trichome 4.5–5 μ broad, short, blue-green, regularly spirally coiled, spirals 11–12 μ broad and 9.5–11 μ distant.

Among other algae in a paddy-field between Kosgoda and Urahaighesmahendai (West and West, 1902, 205) and in pool near Tiruppanawewa and Tank Yahaianagahuwewa near Haberane in Ceylon (Crow, 1923b, 141), in stagnant tank, Pallichal, Travancore (Parukutty, 1940, 119), in a pond in Madras ( ! ).

The species is highly variable. The Travancore plant is 3.3–4.5 μ broad and the spirals are 10.5–12 μ distant. The Madras plant is 3.9–5.2 μ broad and its spirals are 7.9–9.2 μ broad and 9.2–10.5 μ distant.

West (J. Linn. Soc., Bot., 38: 179, 1907) has amended this species. *Spirulina gomontii* Gutw., and *S. gigantea* Schmidle are included under this species by Drouet (Amer. J. Bot., 24: 608, 1937).

### 8. **Spirulina gigantea** Schmidle

Engler's Bot. Jahrb., 32: 59, pl. 1, fig. 5, 1902; Forti, in De Toni, Sylloge Algarum, 5: 210, 1907; Frémy, Myxo. d'Afr. équat. franc., 236, fig. 209, 1929; Geitler, Kryptogamenflora, 930, 1932.

Pl. 36, Figs. 12, 14–17

Trichome 3–4 μ broad, deep blue-green, regularly spirally coiled, at the end conical attenuated, spirals 11–16 μ broad.

Free-floating in lakes and canals. — Rangoon (Ghose, 1925, 246; 1927, 79) and on water plants, Kamayut and Rangoon (Skuja, 1949, 44).

Skuja's plant (1949, pl. 7, figs. 20–22) differs from Schmidle's — Filaments 2.7–4 μ broad, 50-2 μ long, spirals 8–11 μ broad and 7–12 μ separated; cells 1½–2½ times as long as broad. According to him the cross-walls are apparently well seen. The species may have to be transferred to *Arthrospira*.

## SPECIES INQUIRENDA

**Spirulina oscillarioides** Turpin *non* Kütz. *non* Rabenh.

N. India (Turner, 1892, 13), Salt lakes, Calcutta (Martens, 1871a, 173; Prain, 1905, 333).

## OSCILLATORIA Vaucher

Hist. conf., 165, 1803; Gomont, Monogr. Oscillariées, 198, 1892.

Trichome single or forming a flat or spongy free-swimming thallus, sheath absent, rarely with a more or less very delicate sheath, motile, mostly by a creeping movement causing rotation on the longitudinal axis; end of trichome distinctly marked, pointed, bent like a sickle or coiled more or less like a screw. Hormogones formed by the division of the trichome.

Type species: *O. princeps* Vaucher.

### KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Cells up to ⅓ as long as broad | 2 |
| 1. | Cells longer | 17 |
| 2. | Trichome distinctly attenuated | 15 |
| 2. | Trichome otherwise | 3 |
| 3. | Trichome constricted | 4 |
| 3. | Trichome unconstricted | 10 |
| 4. | In freshwater | 6 |
| 4. | In brackish or salt water | 5 |
| 5. | Trichomes 17–29 μ broad | 1. *O. margaritifera* (p. 202) |
| 5. | Trichomes 7–11 μ broad | 2. *O. nigroviridis* (p. 202) |
| 5. | Trichomes 4–11 μ broad | 3. *O. miniata* (p. 202) |
| 6. | Trichomes 7.5–8 μ broad | 4. *O. annae* (p. 203) |
| 6. | Trichomes broader | 7 |
| 7. | Trichomes straight, slightly capitate | 8 |
| 7. | Trichomes spirally coiled, not capitate | 9 |
| 8. | Trichomes constricted, 10–20 μ broad | 5. *O. sancta* (p. 203) |
| 8. | Trichomes unconstricted, 8–10 μ broad | 6. *O. vizagapatensis* (p. 205) |
| 9. | Trichomes 13–15 μ broad, slightly attenuated | 7. *O. perornata* (p. 205) |
| 9. | Trichomes 9–11 μ broad, not attenuated | 8. *O. ornata* (p. 206) |
| 10. | Trichomes straight | 11 |
| 10. | Trichomes bent or spirally coiled | 13 |

11. End cell with a thickened outer wall.......................... 9. *O. limosa* (p. 206)
11. End cell without a thickened outer wall .................................................. 12
    12. Trichomes about 4 µ broad .................... 10. *O. obscura* (p. 207)
    12. Trichomes 5–6 (or 10–10.5) µ broad ............ 11. *O. subbrevis* (p. 207)
13. Trichomes 4 µ broad .................................... 10. *O. obscura* (p. 207)
13. Trichomes broader ............................................................... 14
    14. End cell rounded............................ 12. *O. curviceps* (p. 209)
    14. End cell slightly capitate ........................ 13. *O. princeps* (p. 210)
15. Trichomes up to 8 µ broad........................................................ 17
15. Trichomes broader .............................. 15. *O. proboscidea* (p. 211)
    16. Trichomes 7.5–8 µ broad, not capitate .............. 4. *O. annae* (p. 203)
    16. Trichomes 6–8 µ broad, capitate ................ 14. *O. anguina* (p. 210)
17. Trichomes with a characteristic yellow color ..................................... 18
17. Trichome blue-green ............................................................ 22
    18. Trichomes attenuated ...................................................... 19
    18. Trichomes not attenuated .................................................. 20
19. Trichomes 3–5 µ broad ............................ 16. *O. laete-virens* (p. 213)
19. Trichomes 4.7–6.5 µ broad, gradually tapering......... 17. *O. subuliformis* (p. 213)
    20. Trichomes up to 2.5 µ broad ............. 18. *O. subtilissima* (p. 215)
    20. Trichomes broader ......................................................... 21
21. Trichomes with cells up to 2 µ long ................ 19. *O. chilkensis* (p. 215)
21. Trichomes with cells 4–8 µ long ...................... 20. *O. chlorina* (p. 215)
    22. Apices or portions of trichomes spirally coiled ........................... 23
    22. Apices not so coiled, ends only bent or curved ............................ 27
23. Trichome capitate ............................................................... 24
23. Trichomes not capitate .......................................................... 26
    24. Apices prominently capitate ................ 21. *O. grunowiana* (p. 216)
    24. Apices not so prominently capitate......................................... 25
25. Cells shorter or as long as broad, septa not granulated ........ 22. *O. martini* (p. 216)
25. Cells as long as or longer than broad, septa granulated ....... 23. *O. willei* (p. 217)
    26. Trichomes 3–6.5 µ broad, not constricted at the cross-walls
24. *O. terebriformis* (p. 217)
    26. Trichomes 6–8 µ broad, constricted at the cross-walls 25. *O. boryana* (p. 218)
27. Apices distinctly attenuated .................................................... 53
27. Apices not distinctly attenuated ................................................ 29
    28. Cells shorter than long ................................................... 29
    28. Cells longer than broad ................................................... 40
29. Trichomes distinctly constricted at the cross-walls ............................. 30
29. Trichomes not so constricted .................................................... 33
    30. Trichomes 8–13 µ broad ..................... 26. *O. chalybea* (p. 218)
    30. Trichomes narrower ........................................................ 31
31. Trichomes 3 µ broad .................................... 27. *O. foreaui* (p. 219)
31. Trichomes broader ............................................................... 32
    32. Trichomes 5–7 µ broad, marine ............ 28. *O. corallinae* (p. 221)
    32. Trichomes 6–7 µ broad, not marine............... 29. *O. proteus* (p. 221)
33. Trichomes broader than 10 µ........................ 30. *O. decolorata* (p. 221)
33. Trichomes less broader .......................................................... 34
    34. Trichomes broader than 5 µ ................................................ 35
    34. Trichomes less narrower than 5 µ .......... 31. *O. jasorvensis* (p. 221)

35. Trichomes unconstricted .................................... 36
35. Trichomes constricted .................................... 37
36. With gas vacuoles .................................... 32. *O. mougeotii* (p. 222)
36. Without gas vacuoles .................................... 38
37. Trichomes 4–10 μ broad, apical cells with a thickened outer membrane
33. *O. tenuis* (p. 222)
37. Trichomes 6–9 μ broad .................................... 34. *O. nigra* (p. 223)
37. Trichomes 5.2–6 μ broad .................................... 35. *O. raoi* (p. 223)
38. With a thickened outer wall or membrane .................................... 39
38. Without a thickened outer membrane .................................... 36. *O. simplicissima* (p. 224)
39. Cells ½ to as long as broad .................................... 37. *O. irrigua* (p. 224)
39. Cells shorter .................................... 6. *O. vizagapatensis* (p. 205)
40. Trichomes constricted at the cross-walls .................................... 41
40. Trichomes not constricted at the cross-walls .................................... 46
41. Trichomes 1 μ broad .................................... 38. *O. fremyii* (p. 225)
41. Trichomes broader .................................... 42
42. Trichomes up to 2 μ broad .................................... 45
42. Trichomes broader .................................... 43
43. Trichomes circinate .................................... 39. *O. gloiophila* (p. 225)
43. Trichomes not circinate .................................... 44
44. Trichomes 2-5 μ broad, constricted, cells mostly shorter than broad
40. *O. minnesotensis* (p. 225)
44. Trichomes 4.8–5 μ broad, slightly constricted, cells mostly longer than broad
41. *O. hamelii* (p. 225)
45. Trichomes with cells 2½–8 times as long as broad .................................... 42. *O. limnetica* (p. 226)
45. Trichomes with cells 1–2 times as long as broad, with prominent granules at the cross-walls .................................... 43. *O. amphigranulata* (p. 226)
46. Trichomes up to 1 μ broad .................................... 47
46. Trichomes broader .................................... 48
47. Trichomes 0.6 μ broad .................................... 44. *O. angustissima* (p. 227)
47. Trichomes 0.8–1.2 μ broad .................................... 45. *O. angusta* (p. 227)
48. Trichomes up to 1–2.2 μ broad .................................... 49
48. Trichomes broader .................................... 51
49. Cells 2–4 times as long as broad, with two granules one either side of the septa
46. *O. quadripunctulata* (p. 227)
49. Cells as long as or somewhat longer than broad .................................... 50
50. Septa granulated, 1 or 2 granules .................................... 47. *O. trichoides* (p. 228)
50. Septa not granulated .................................... 48. *O. pseudogeminata* (p. 228)
51. Trichomes 2–3 (–3.5) μ broad, cells 4–8.5 μ long, septa granulated
49. *O. amphibia* (p. 229)
51. Trichomes 2.5 μ broad, cells 3–3.5 μ long, septa not granulated
50. *O. geitleriana* (p. 230)
52. Trichomes constricted at the cross-walls .................................... 53
52. Trichomes not constricted at the cross-walls .................................... 61
53. End cells capitate .................................... 51. *O. amoena* (p. 230)
53. End cells not capitate .................................... 54
54. End cells conical, attenuated .................................... 55
54. End cells rounded .................................... 59
55. Cells up to ½ as long as broad .................................... 52. *O. okeni* (p. 231)

55. Cells longer .......... 56
56. Cells more or less as long as broad .......... 57
56. Cells 3–5 times as long as broad .......... 53. *O. claricentrosa* (p. 231)
57. Trichomes less than 3 μ broad .......... 54. *O. schultzii* (p. 232)
57. Trichomes broader .......... 58
58. Trichomes 4–6 μ broad .......... 55. *O. formosa* (p. 232)
58. Trichomes 5–5.8 μ broad, cells quadrate or longer.. 56. *O. cortiana* (p. 233)
59. Cells ½–⅓ as long as broad .......... 60
59. Cells quadrate or somewhat shorter than broad .......... 57. *O. tanganyikae* (p. 233)
60. Trichomes 7.5–8 μ broad .......... 4. *O. annae* (p. 203)
60. Trichomes 8–13 μ broad .......... 26. *O. chalybea* (p. 218)
61. End cell capitate .......... 62
61. End cell not capitate .......... 64
62. Cells as long as or distinctly shorter than broad .......... 63
62. Cells longer than broad .......... 58. *O. splendida* (p. 234)
63. Cells as long as broad, 2.2–5 μ broad .......... 59. *O. prolifica* (p. 234)
63. Cells distinctly shorter than broad, 6–8 μ broad .......... 60. *O. rubescens* (p. 235)
64. With gas vacuoles .......... 65
64. Without gas vacuoles .......... 66
65. Trichomes 4–6 μ broad .......... 61. *O. agardhii* (p. 235)
65. Trichomes 8–9 μ broad .......... 62. *O. raciborskii* (p. 236)
66. Trichomes up to 2.5 μ broad .......... 67
66. Trichomes up to 10 μ broad .......... 73
67. Cells shorter than broad .......... 72. *O. animalis* f. *tenuior* (p. 240)
67. Cells up to 2–3 times as long as broad .......... 68
68. Trichomes up to 0.9–1 μ broad .......... 63. *O. deflexa* (p. 236)
68. Trichomes up to 2.5 μ broad .......... 69
69. Cross-walls granulated .......... 70
69. Cross-walls not granulated .......... 71
70. With three distinct granules on either side .... 64. *O. calcuttensis* (p. 237)
70. With many granules .......... 65. *O. lemmermannii* (p. 237)
71. Trichomes 1.5–2 μ broad, often with 1–2 gas vacuoles at the cross-walls 66. *O. acutissima* (p. 237)
71. Trichomes up to 2.5 μ broad, without gas vacuoles .......... 72
72. Trichomes 1.8–2 μ broad, cell somewhat longer .67. *O. kuetzingiana* (p. 237)
72. Trichomes 2.2—2.4μ broad, cells up to 2½ times as long as broad. 68. *O. earlei* (p. 238)
73. Apical cell broadly rounded .......... 74
73. Apical cell otherwise .......... 75
74. Trichomes up to 6 μ broad .......... 69. *O. subproboscidea* (p. 238)
74. Trichomes up to 8.2–9 μ broad .......... 70. *O. paucigranata* (p. 238)
75. Cells up to ½ as long as broad .......... 76
75. Cells longer .......... 78
76. Trichomes 4–6 μ broad, cross-walls granulated .......... 79
76. Trichomes narrower, cross-walls not granulated .......... 77
77. Trichomes 3–6 μ broad; apex bent with hyaline pointed cell 71. *O. salina* (p. 239)
77. Trichomes 3–4 μ broad; end cell conical pointed. ........72. *O. animalis* (p. 239)
78. Cells longer than broad, rarely quadrate .......... 73. *O. acuminata* (p. 240)
78. Cells shorter .......... 74. *O. acuta* (p. 240)
79. Apex of the trichomes straight, rarely slightly curved .......... 75. *O. cruenta* (p. 241)
79. Apex briefly tapering, hooked or flexuous .......... 76. *O. brevis* (p. 241)

### 1. **Oscillatoria margaritifera** (Kütz.) Gomont

Monogr. Oscillariées, 216, pl. 6, fig. 19, 1892; Forti in De Toni, Sylloge Algarum, 5: 161, 1907; Geitler, Kryptogamenflora, 942, fig. 597b, 1932; Frémy, Cyano. cotes d'Eur., 120, pl. 31, fig. 1, 1933.

Pl. 42, Fig. 8

Trichome olive-green, forming blackish thallus, 17–29 μ broad, fragile, straight, constricted at the cross-walls, apices slightly bent, slightly attenuated; cells 1/3–1/7 as long as broad, 3–6 μ long, cross-walls granulated, end-cell capitate with slightly convex calyptra.

Trincomalie Harbour, Ceylon (Crow, 1923b, 141).

### 2. **Oscillatoria nigroviridis** Thwaites ex Gomont

Thwaites in Harvey Phyc. Brit. Syn., 39, nr. 375, pl. 251A, 1846–1851; Gomont, Monogr. Oscillariées, 217, pl. 6, fig. 20, 1892; Geitler, Kryptogamenflora, 942, 597C, 1932; Frémy, Cyano. cotes d'Eur., 120, pl. 30, fig. 8, 1933.

Pl. 42, Fig. 6 & Pl. 49, Fig. 2

Thallus expanding, dark green. Trichome olive-green, 7–11 μ broad, constricted at the cross-walls, bent at the ends and attenuated. Cells 1/2–1/4 as long as broad, 3–5 μ long, cross-walls granulated, end-cells slightly capitate with a slightly thickened convex outer membrane.

In salt water puddles and creeks, Mogaltur (Rao, C. B., 1938a, 90), in rain water puddles, Puri (Rao, C. B., 1938b, 164), on the sides of a pond, Veli, Kerala (Parukutty, 1940, 120), Plankton, Madras Coast (Iyengar and Desikachary, 1944, 56), Cape Comorin (Venkataraman, 1957, 472).

Parukutty's specimens appear to be very much different from *O. nigroviridis* (lat. fil., 3.3–7 μ ; cells 1.5–2.2 μ long).

### 3. **Oscillatoria miniata** (Zanard.) Hauck ex Gomont

Hauck, Die Meeresalgen, 508, 1885; Gomont, Monogr. Oscillariées, 216, 1892; Forti in De Toni, Sylloge Algarum, 5: 160, 1907; emend. Frémy, Cyano. cotes d'Eur., 119, pl. 30, fig. 7, 1938.

Pl. 40, Fig. 17

Thallus solid, pale red, or black olivaceous, expanded; trichome straight, flexuous, torulose, 16–24 μ broad, apex not attenuated or briefly attenuated, obtuse, cells 1/2–1/6 as long as broad, (4–) 7–11 μ long, contents homogeneous, sparsely granulated, cross-walls granulated; apex capitate, apical cell with slightly convex calyptra.

Galle, Ceylon (Boergesen, 1936, 60).

Frémy (1934) gives a more complete description of this species. The cells are 4–11 μ long, with two granules on either side of the septa.

### 4. **Oscillatoria annae** van Goor

Zur Kenntnis des Oscillatoriaceen, Rec. Trav. bot. néerland., 15: 289, pl. 2, fig. 1a-c, 1918; Geitler, Kryptogamenflora, 943, 1932.

Pl. 38, Fig. 13

Trichome straight, dull blue-green, slightly constricted at the cross-walls, 7.5–8 μ broad; mostly attenuated at the ends, up to 7 μ broad and bent; cells 1/3–1/5 as long as broad, 1.5–3 sometimes up to 4 μ long, not granulated at the cross-walls; end-cell rounded, calyptra absent.

On breathing roots of Mangroove trees, Kamaw, Kisseraing Island (Ghose, 1927c, 249); attached to leaves along with other algae, River Yamuna near Allahabad (Gupta, 1956, 78).

### 5. **Oscillatoria sancta** (Kütz.) Gomont

Monogr. Oscillariées, 209, pl. 6, fig. 12, 1892; Forti in De Toni, Sylloge Algarum, 5: 153, 1907; Frémy, Myxo d'Afr. équat. franc., 211, fig. 177, 1929; Geitler, Kryptogamenflora, 943, fig. 598c, 1932.

(inkl. f. *tenuis* Parukutty, 1940, p. 120).

Pl. 42, Fig. 10

Thallus dark blue, shining, thin, gelatinous; trichomes straight or bent, distinctly constricted at the cross-walls; ends briefly attenuated, 10–20 μ broad, dull blue-green or olive-green; cells 1/3–1/6 times as long as broad, 2.5–6 μ long, granulated at the cross-walls. End-cell flattened, hemispherical, slightly capitate, with a thickened membrane.

On wet or moist walls or soil, free-floating or on leaves in freshwater or salt water ponds and lakes.—Hanzadah (Zeller, 1873b, 177; also Theobald, 1883, 24) and Rangoon (Skuja, 1949, 49) in Burma; Bombay (Schmidle, 1900b, 162; Gonzalves and Joshi, 1946, 176), Benaras (Rao, C. B., 1937b, 365), Cuttack (Rao, C. B., 1938b, 164), Dhapa in Bengal (Banerji, 1938, 101), Madhupani in Bihar (Rao, C. S., 1939, 149), New Delhi (Rao, C. S., 1940, 129) and Yamuna River near Allahabad (Gupta, 1956, 78) in India.

Dixit (1936, 103) describes a form from a rainwater pool, Dharavi Road, Mahim near Bombay, which has thinner trichomes (Trichomes 7.5–10 μ broad and cells 2–2.5 μ long). Skuja (1949) has described the trichomes as being only a little constricted. Rao, C. B. (1937b, 366) describes from Benaras a form with unconstricted trichomes (9.6–11.2 μ broad and cells 2–4 μ long). Parukutty (1940, 120) described forma *tenuis*.—trichomes 6.6–7 μ broad and

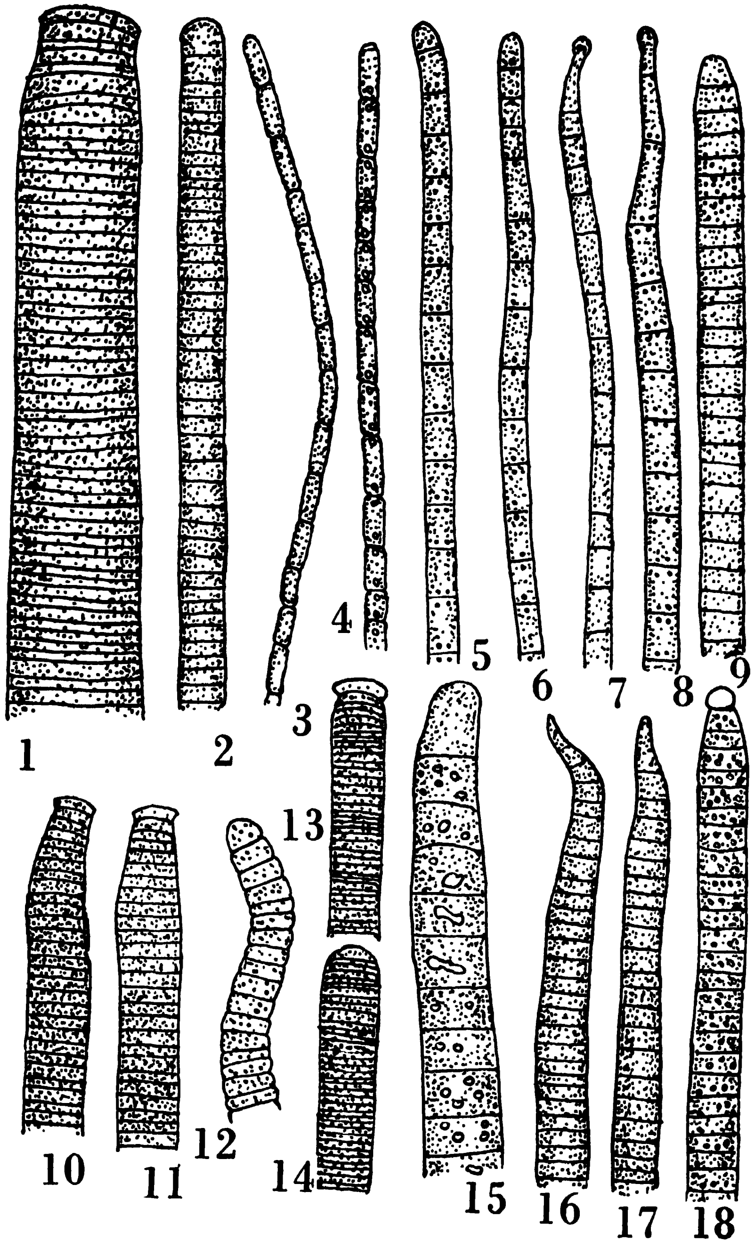

PLATE 37, Figs. 1–18.

1. *Oscillatoria princeps* Vaucher (orig.); 2. *O. subbrevis* Schmidle (orig.); 3. *O. limnetica* Lemm. (orig.); 4. *O. amphigranulata* van Goor (orig.); 5. *O. quadripunctulata* Bruhl & Biswas (orig.); 6. *O. amphibia* Ag. (orig.); 7 & 8. *O. splendida* Grev. (orig.); 9, 18. *O. rubescens* f. forma (orig.); 10, 11, 13, 14. *O. princeps* Vaucher (after Frémy); 12. *O. ornata* Kütz. (after Gomont); 15. *O. raciborskii* Wolosz. (orig.); 16, 17. *O. salina* biswas f. *major* f. n. (orig.).

cells 1.6–2 μ long.—In a stagnant tank, Trivandrum. This form seems to be narrower than the one described by Dixit. Obviously it appears as if the species has a wide range of variation in its dimensions. Already there are quite a few varieties which cover the dimensions of the forms given above. It seems best to merge all the varieties in the type of the species itself and amend the diagnosis of the species as—Trichomes 6.6–20 μ broad, generally constricted, sometimes only slightly or unconstricted. More so because some of these forms have been found occurring with the (type of the) species itself and may well represent a normal form variation (see var. *aequinoctinalis* Gom. and also forma Rao, C. B., 1937b, 366). A very similar condition exists in *O. princeps* and *O. limosa* (*see* Geitler, 1932, 944).

### 6. **Oscillatoria vizagapatensis** Rao, C. B.

Myxophyceae of the Madras Presidency, J. Indian bot. Soc., 17: 89, figs. 1–3, 1938a.

Pl. 39, Figs. 16, 18

Thallus blue-green; trichomes straight, or bent, pale blue-green, uniformly broad except at the extreme apex, 8–10 μ broad, without constrictions at the cross-walls; cells much shorter than broad, 1.6–2 μ long, contents granular; end cell broadly rounded forming a cap with a slightly thickened outer wall.

On moist rocks in a dark and shady cove in a hillock, Vizagapatam, in Andhra State (Rao, C. B., *loc. cit.*).

### 7. **Oscillatoria perornata** Skuja

Zur Süsswasseralgenflora Burmas, Nov. Acta Reg. Soc. Uppsal., ser. 4, 14: 47, pl. 8, figs. 7–9, 1949.

Pl. 41, Figs. 8, 9, 14

Trichomes erect and flexuous, apices briefly attenuated and bent or curved, well constricted at the cross-walls, 13–15 μ broad, single or aggregated in floccose masses; cells commonly 1/2–1/5 as long as broad, 2.5–6.5 μ long, contents pallide tenerumgue aeruginius, finely granular, septa more or less granulated, end cell humilis depressed hemispherical, calyptra absent.

Planktonic in Kokine lakes, Rangoon and at Kamayut in Burma (Skuja, *loc. cit.*).

### f. **attenuata** Skuja

Skuja, *loc. cit.*, 47, pl. 8, fig. 10, 1949.

Trichomes narrower, 10–12 μ broad, ends prominently attenuated, cells 1/2–1/3 as long as broad, pale blue-green with or without gas-vacuoles.

Free floating in Cantonment gardens, Rangoon in Burma (Skuja, *loc. cit.*).

### 8. **Oscillatoria ornata** Kütz. ex Gomont

Kützing, Tab. Phycologicae, 1: 30, pl. 42, fig. 9, 1846; Gomont, Monogr. Oscillariées, 214, pl. 6, fig. 15, 1892; Forti in De Toni, Sylloge Algarum, 5: 158, 1907; Frémy, Myxo. d'Afr. équat. franc., 212, fig. 179, 1929; Geitler, Kryptogamenflora, 944, fig. 599a, 1932.

Pl. 37, Fig. 12 & Pl. 40, Fig. 3

Thallus dark blue-green; trichome spirally coiled at the ends, constricted at the cross-walls, 9–11 μ broad, dull blue-green, cells 1/2–1/6 as long as broad, 2–5 μ long, cross-walls granulated; apices slightly attenuated; end-cells rounded, not capitate, without thickened membrane.

In a pond, Polamur (Rao, C. B., 1938a, 90); Plankton in River Cauvery at Seringapatam in Mysore ( ! ).

The cells in the Indian form are 3.3–6 μ long.

#### Var. **crassa** Rao, C. B.

The Myxophyceae of the Orissa Province I, Proc. Indian Acad. Sci., B, 8: 165, fig. 20, 1938b.

Pl. 39, Fig. 11

Thallus dark blue-green; trichome straight, of uniform thickness, 11–15 μ broad, constricted at the cross-walls, cross-walls granulated; cells shorter than broad, 2–5.5 μ long; end-cell convex without calyptra, not capitate.

In ponds, Cuttack (Rao, C. B., *loc. cit.*); and Kamayut in Burma (Skuja, 1949, 47).

### 9. **Oscillatoria limosa** Ag. ex Gomont

Agardh, Dispositio Algarum Sueciae, 35, 1812; Gomont, Monogr. Oscillariées, 210, pl. 6, fig. 13, 1892; Forti in De Toni, Sylloge Algarum, 5: 154, 1907; Frémy, Myxo. d'Afr. équat. franc., 212, fig. 178, 1929; Geitler, Kryptogamenflora, 944, fig. 598d, 1932; Frémy, Cyano. cotes d'Eur., 117, pl. 30, fig. 4, 1933.

Pl. 42, Fig. 11

Thallus dark blue-green to brown; trichome more or less straight, dull blue-green, brown or olive-green, not constricted at the cross-walls, or only slightly constricted, 11–20 (–22) μ, commonly 13–16 μ broad; cells 1/3–1/6 as long as broad, 2–5 μ long, cross-walls frequently granulated; end-cell flatly rounded with slightly thickened membrane.

In a standing fresh and salt waters.— Howrah, Calcutta Salt lakes, River Hooghly in Bengal (Martens, 1870b, 258; also Prain, 1905, 333; Martens, 1871a, 170, also Prain, 1905, 330; Biswas, 1926, 18; 1942, 199); Central India (Turner, 1892, 3); Hyderabad (Ghousuddin, 1936, 150), Berhampur in Orissa (Rao, C. B., 1938b, 165); Madras (Ganapathi, 1940a, 246); Perediniya, Tank Andankulam, Tank Nawawewa near Anuradhapura, Madukotaikulam, salt lagoon near Trincomalie and Yaha-anagahuwewa near Haberan in Ceylon (West, 1902, 204; Crow, 1923b, 141); Royal lakes, Rangoon and Tanuggyi canal, Maymyo and Myoingam in Burma (Ghose, 1927b, 239; Skuja, 1949, 46); Setapak in Kuala Lumpur, Malaya (Biswas, 1929, 408).

Biswas described f. *constricta* from Malaya which is included in the species itself (*see* Geitler, 1932, 944; Huber-Pestalozzi, 1938, 233).

### 10. **Oscillatoria obscura** Bruhl et Biswas

Algae of the Bengal Filter Beds, J. Dept. Sci., Calcutta Univ., 4: 6, pl. 2, fig. 9, 1922; Geitler, Kryptogamenflora, 945, 1932.

Trichome about 4 μ broad, attenuated at the apex, rounded, slightly bent or nearly straight, blue-green, not constricted at the cross-walls; cells about 1/5 as long as broad or shorter, cross-walls granulated.

Filter beds or ponds, Berhampur in Orissa (Bruhl and Biswas, *loc. cit.*; Rao, C. B., 1938b, 165); on wet soil, Benaras (Rao, C. B., 1937b, 366); in a drain in Poojapara and water channel, Karamam in Travancore (Parukutty, 1940, 120).

According to these later records of the species the trichomes are 3.3–4.8 μ broad and the cells are 1–1.6 μ long.

### 11. **Oscillatoria subbrevis** Schmidle

Engler's Bot. Jahrb., 30; 243, pl. 4, fig. 7, 1901; Forti in De Toni, Sylloge Algarum, 5: 208, fig. 174, 1907; Frémy, Myxo. d'Afr. équat. franc., 208, fig. 174, 1929; Geitler, Kryptogamenflora, 949, fig. 601b, 1932.

Pl. 37, Fig. 2 & Pl. 40, Fig. 1

Trichomes single, 5–6 μ broad, nearly straight, not attenuated at the apices; cells 1–2 μ long, not granulated at the cross-walls; end-cell rounded, calyptra absent.

On the moist banks of River Ravi, Punjab (Singh, V. P., 1941, 252) and in temporary rainwater pools at Borivli, Bombay (Gonzalves and, Joshi 1943a, 37).

Singh, V. P. records the trichome to be 4.9–6.8 μ broad and its cells 1.5–2.5 μ long.

Dixit describes another form.—trichomes 7.5–10 μ broad, cells 1.2–1.5 μ long—on moist soil, Borivli, Bombay (Dixit, 1936, 103).

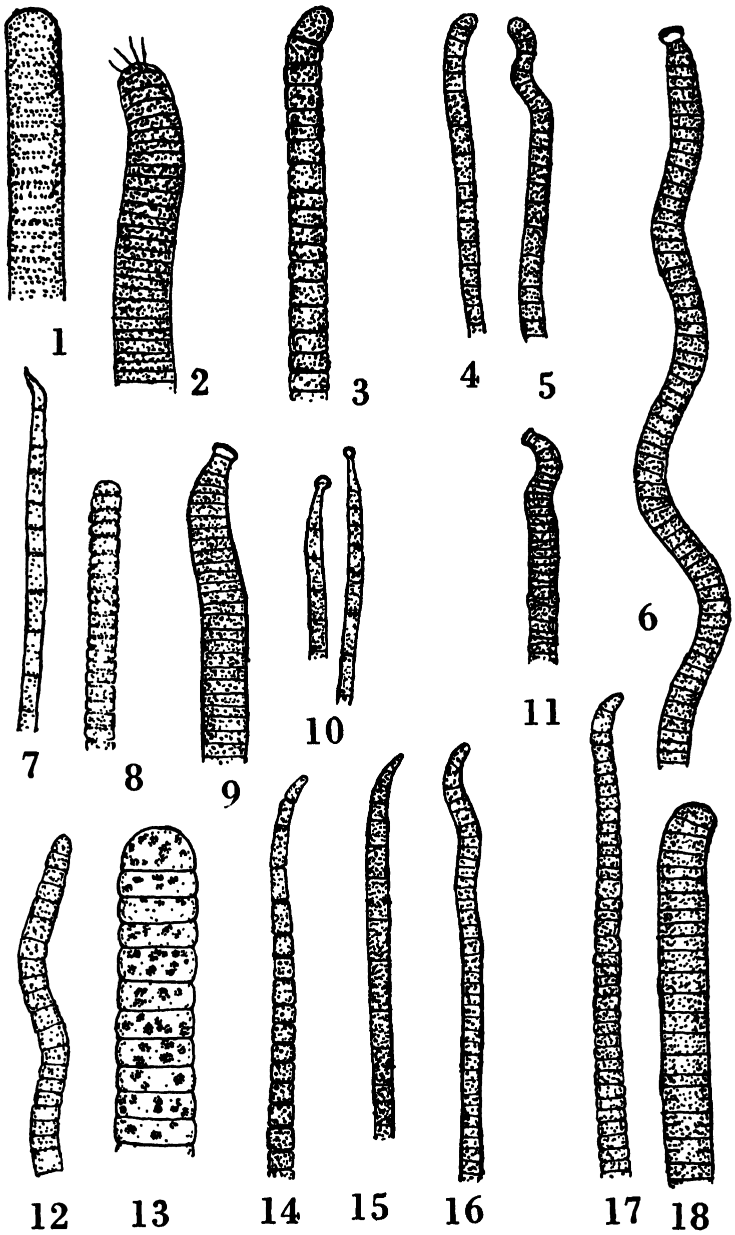

PLATE 38, Figs. 1–18.

1. *O. limosa* Ag. (after Gomont); 2. *O. curviceps* Ag. (after Gomont); 3. *O. chlaybe* Martens (after Gomont); 4, 5. *O. willei* Gardner em. Drouet (after Gardner); 6. *O. martin* Frémy (after Frémy); 7. *O. acuminata* Gom. (after Gomont); 8. *O. tenuis* Ag. (after Gomont) 9. *O. proboscidea* Gom. (after Gomont); 10. *O. splendida* Grev. (after Gomont); 11. *O* *anguina* (Bory) Gom. (after Gomont); 12. *O. boryana* Bory (after Gomont); 13. *O. annae* var Goor (after van Goor); 14. *O. cortiana* Menegh. (after Gomont); 15. *O. earlei* Gardner (afte Gardner); 16. *O. terebriformis* Ag. (after Frémy); 17. *O. okeni* Ag. (after Gomont); 18. *O* *chalybea* v. *insularis* Gardner (after Gardner).

f. **crassa** Dixit

Myxo. Bombay Pres. I, Proc. Indian Acad. Sci., B, 3: 103, 1936.
Trichomes 12.5–20 μ broad, cells 2.5–3 μ long.
On moist soil, Borivli, Bombay (Dixit, *loc. cit.*)

f. **major** West, G. S.

J. Linn. Soc. (Lond.) Bot., 38: 78, 1907.

Trichome 10–10.5 μ broad.

On moist soil, Benaras (Rao, C. B., 1936, 171).

According to Rao the trichomes are 9.5–10 μ, cells 1–1.8 μ long in the Benaras alga.

forma **minor** f. nov.

Trichomes 3.9–5.2 μ broad, cells 3–2 μ long.

In stagnant waters, Saidapet, near Madras.

12. **Oscillatoria curviceps** Ag. ex Gomont

Agardh, Syst. Alg., 68, 1824; Gomont, Monogr. Oscillariées, 213, pl. 6, fig. 14, 1892; Forti in De Toni, Sylloge Algarum, 5: 157, 1907; Geitler, Kryptogamenflora, 947, fig. 598e, 1932; Frémy, Cyano. cotes d'Eur., 117, pl. 30, fig. 5, 1933.

Pl. 38, Fig. 2

Thallus light or dark blue-green; trichomes more or less straight, bent at the end or spirally coiled, not attenuated or very little attenuated, not constricted at the cross-walls, 10–17 μ broad, cells 1/3–1/6 as long as broad, 2–5 μ long, cross-walls sometimes granulated; end-cells flat rounded, not capitate.

Planktonic in Gregory and Colombo lakes Ceylon (Lemmermann, 1907, 264).

Rao, C. B.,'(Myxo. Orissa Province, I, Proc. Indian Acad. Sci., 8: 165, 1938b.) describes a form.

Pl. 39, Figs. 9, 10

Trichome 14–17.8 μ broad, cells 2–4 μ long, apices straight.

In a pond, Cuttack (Rao, C. B., *loc. cit.*).

Parukutty, (Myxo. Travancore State, India, Proc. Indian Acad. Sci., 11: 120, 1940.) describes a form.

Trichome 6.6–11.1 μ broad, cells 1.5–2 μ long.

In a rice field, Parakad, Travancore (Parukutty, *loc. cit.*).

Var. **angusta** Ghose

The Myxophyceae of Rangoon—III, J. Burma Res. Soc., 7: 240, pl. 2, fig. 6, 1927b; Geitler, Rabenhorst's Kryptogamenflora, 948, 1932.

Pl. 39, Fig. 12

Trichome 5–10 μ broad.

In royal lakes, Rangoon (Ghose, *loc. cit.*).

13. **Oscillatoria princeps** Vaucher ex Gomont

Vaucher, Histoire des conferves d'eau douce, 190, pl. 15, fig. 2, 1803; Gomont, Monogr. Oscillariées, 206, pl. 6, fig. 9, 1892; Forti in De Toni, Sylloge Algarum, 5: 150, 1907; Frémy, Myxo. d'Afr. équat. franc., 208, fig. 175, 1929; Geitler, Kryptogamenflora, 947, figs. 598a, 601-cg, 1932.

Pl. 37, Figs. 1, 10, 11, 13, 14

Trichomes blue-green, more or less brownish, violet or reddish, mostly forming a thallus, mostly straight, not constricted at the cross-walls, 16–60 μ broad, commonly 25–50 μ, blue-green to dirty green, slightly or briefly attenuated at the apices and bent; cells 1/11–1/4 as long as broad, 3.5–7 μ long; end-cells flatly rounded, slightly capitate without or with slightly thickened membrane.

In freshwater, sea-water floating and in moist soil. Cosmopolitan, all over India, Ceylon, Burma and Pakistan.

Geitler (1932, p. 947) considers this species as a mixture with variation in colour, cell-dimensions, etc. Experimental studies are needed. According to Geitler the end-cell has gas-vacuoles.

Var. **pseudolimosa** Ghose

J. Linn. Soc. (Lond.) Bot., 46: 337, pl. 31, fig. 2, 1924.

Pl. 39, Figs. 15, 17

Thallus blue-green, trichome straight, rigid, and fragile, when dried unconstricted at the cross-walls, cross-walls not granulated, 31–35 μ broad; cells short, protoplasm granular, apices straight, apical cell slightly convex, calyptra absent.

Attached to mud, later free-floating in a slow flowing dirty drain, Lahore (Ghose, 1924, 337).

14. **Oscillatoria anguina** (Bory) Gomont

Monogr. Oscillariées, 214, pl. 6, fig. 16, 1892; Forti in De Toni, Sylloge Algarum, 5: 159, 1907; Geitler, Kryptogamenflora, 948, fig. 599b, 1932.

Pl. 38, Fig. 11

Thallus dark blue-green; trichome straight, at the ends spirally coiled and distinctly attenuated, not constricted at the cross-walls, 6–8 μ broad, cross-walls sometimes granulated; cells 1/3–1/6 as long as broad, 1.5–2.5 μ long; end-cells capitate, with a slightly thickened membrane.

In standing waters or on moist soil or in cultures of paddy-field soil.—Gregory lake, Ceylon (Lemmermann, 1907, 264), Benaras and Chunar in U.P. (Rao, C. B., 1937b, 366), Polamur in Andhra (Rao, C. B., 1938a, 91), Berhampur in Orissa (Rao, C. B., 1938b, 165), Patna in Bihar (Rao, C. B., 1939, 148), Delhi (Rao, C. S., 1940, 129), Pallichal in Travancore (Parukutty, 1940, 120), Goregaon and Dahisar paddy-field soil, Bombay (Gonzalves and Joshi, 1949, 54).

Parukutty (1940, 120) and Rao, C. S. (1940, 129) record the breadth of trichomes as 5–6.6 μ and 4.5–6.8 μ. Similarly the cells have a length of 1.6–4 μ (*see* Rao, C. S., 1939, 148 and 1940, 129).

Skuja (Zur Süsswasseralgenflora Burmas, 46, pl. 8, figs. 1, 2, 1949.) describes a form.

Pl. 41, Figs. 5, 6

Trichomes more or less straight, also variously bent forming a blue-green thallus, short, ends tapering, capitate, 5.5–8 μ broad, unconstricted or only slightly constricted; cells 1/3–1/6 (1/8) as long as broad, seldom distinctly granulated; end-cells calyptrate.

6th mile Prome Road, Rangoon, Burma.

### 15. **Oscillatoria proboscidea** Gomont

Monogr. Oscillariées, 209, pl. 6, figs. 10, 11, 1892; Forti in De Toni, Sylloge Algarum, 5: 152, 1907; Frémy, Myxo. d'Afr. équat. franc., 211, fig. 176, 1930; Geitler, Kryptogamenflora, 948, fig. 598b, 1932.

Pl. 38, Fig. 9

Thallus dull green to dark blue-green; trichome more or less straight, not constricted at the cross-walls, 12–15 μ broad, at the ends distinctly attenuated, slightly curved or sometimes spirally coiled, brightly blue-green; cells 1/3–1/6 times as long as broad, 2–4 μ long, not granulated at the cross-walls; end-cells flatly rounded, capitate, with slightly thickened membrane.

In standing waters, drains or on moist soil: Tank Balaluwewa and fourth backwater of Mahavilla Ganga below Gampulla in Ceylon (Crow, 1923b, 141); Benaras, Gorakhpur, Mirzapur and Basti in U.P. (Singh, R. N., 1939a, 60; 1939b, 68), New Delhi (Rao, C. S., 1940, 128); Rangoon in Burma (Skuja, 1949, 48).

Gonzalves (1947, 26) describes a form from the Vajreshwari Hot Springs near Bombay, where it occurred at 38°C. The form differs in having slightly narrower trichomes (Trichome 9.4 μ broad; cells 3.2 μ long).

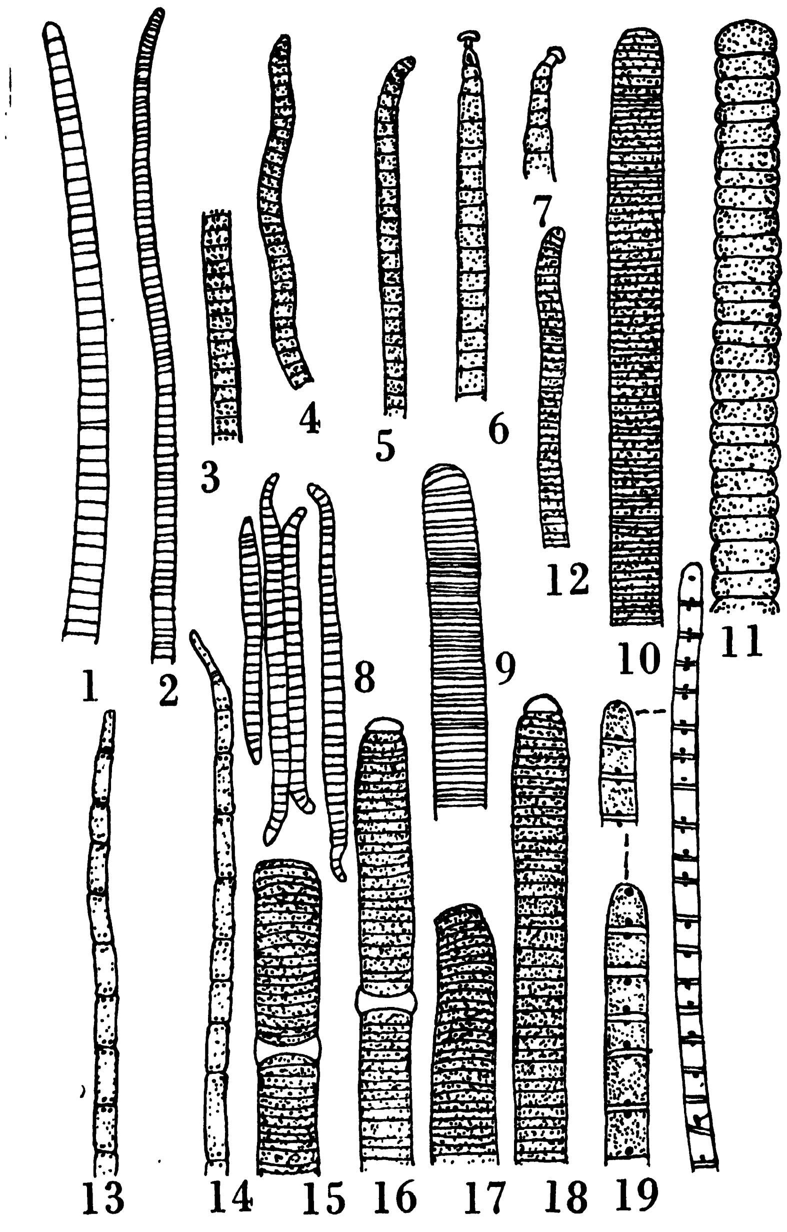

PLATE 39, Figs. 1–19.

1. *O. chilkensis* Biswas (after Biswas); 2, 3. *O. laetevirens* v. *minimus* Biswas (after Biswas); 4. *O. formosa* f. *loktakensis* Biswas (after Biswas); 5, 8. *O. acuta* Bruhl et Biswas (after Bruhl & Biswas); 6, 7. *O. amoena* Gom. v. *nongranulata* Ghose (after Ghose); 9, 10. *O. curviceps* forma (after Rao, C. B.); 11. *O. ornata* var. *crassa* Rao (after Rao, C. B.); 12. *O. curviceps* v. *angusta* Ghose (after Ghose); 13, 14. *O. claricentrosa* f. *bigranulata* Rao (after Rao, C. B.); 15, 17. *O. princeps* v. *pseudolimosa* Ghose (after Ghose); 16, 18. *O. vizagapatensis* Rao (after Rao, C. B.); 19. *O. pseudogeminata* v. *unigranulata* Biswas (after Biswas).

Skuja (1949, pl. 8, fig. 15) describes the dimensions of the trichomes in the Rangoon collections (trichomes 9–10 μ broad, cells 1/4–1/2 as long as broad and with finely granulated cross-walls).

### 16. **Oscillatoria laete-virens** (Crouan) Gomont

Bull. bot. Soc. Fr., 7: 371, 1860; Monogr. Oscillariées, 226, pl. 7, fig. 11, 1892; Forti in De Toni, Sylloge Algarum, 5: 177, 1907; Geitler, Kryptogamenflora, 949, fig. 603c, 1932; Frémy, Cyano. cotes d'Eur., 126, pl. 31, fig. 12, 1933.

Thallus thin, membranous, green; trichome yellowish green, straight, fragile, slightly constricted at the cross-walls, 3–5 μ broad, apices attenuated, undulate or bent; cells nearly as long as broad, 2.5–5 μ long, sometimes granulated at the cross-walls; end-cells not capitate, more or less obtuse or conical, without calyptra.

In salt lakes, Calcutta (Biswas, 1926, 20) and as straggling community and microphytoplankton in the River Hooghly, Calcutta (Biswas, 1942, 196/199); on mud, in stagnant water and soiled trench water, Rangoon (Skuja, 1949, 46).

Biswas (1926) records the diam. as 3–6 μ and Skuja (1949) as 4.5–5.5 μ The Calcutta specimen is also described as having undulated or hooked apices Biswas does not mention about the granulation of the cross-walls. Skuja state that the cross-walls are granulated and only seldom are they non-granulated.

### Var. **minimus** Biswas

Algal flora of the Chilka lake, Mem. Asiatic Soc. Bengal, 11: 187, pl. 28, 1932b.

Pl. 39, Figs. 2, 3

Trichomes 2.5–3 μ in diam., somewhat fragile, slightly constricted at the cross-walls, apex of the trichome slightly tapering, more or less curved, and sinuous, not distinctly hooked; apical cell acute and somewhat pointed, not capitate, calyptra none; cells 1.5–2 μ in length; cross-walls granulated, 3 granules on either side, cell contents uniformly granular, blue-green.

The variety differs in the smaller dimensions and in having uniformly 3 granules on either side of the septa (cf. Skuja's description, 1949, p. 46).

### 17. **Oscillatoria subuliformis** Kütz. ex Gomont

Kützing, Diagnosen und Bemerkungen zu drei und siebenzig neuen Algenspecies, Oster-progress, 7, 1863; Gomont, Monogr. Oscillariées, 226, pl. 7, fig. 10, 1892; Geitler, Kryptogamenflora, 949, fig. 603b, 1932; Frémy, Cyano. cotes d'Eur., 125, pl. 31, fig. 8, 1933. *non* Le Jolis.

Pl. 49, Fig. 10

Thallus dull green; trichomes yellow-green, very long flexuous, and bent, not constricted at the cross-walls, 4.7–6.5 μ broad, at the ends gradually

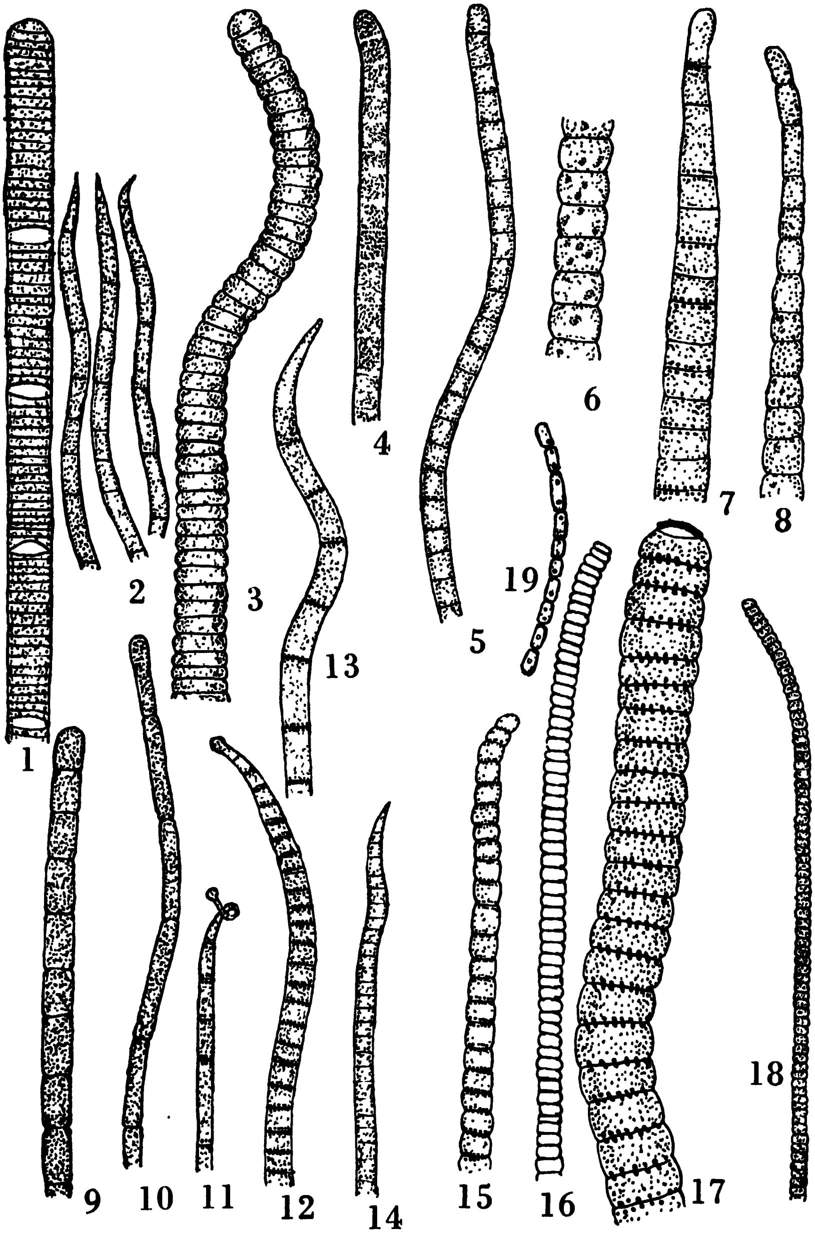

PLATE 40, Figs. 1 -19.

1. *O. subbrevis* Schmidle (after Frémy); 2. *O. claricentrosa* Gardner (after Gardner); 3. *O. ornata* Kütz. (after Frémy); 4. *O. chlorina* Kütz. (after Frémy); 5. *O. homogenea* ( = *O. willei*) Frémy (after Frémy); 6-8. *O. tanganyikae* West, G. S. (after Frémy); 9. *O. geitleriana* (Frémy) Elenkin (after Frémy); 10. *O. lemmermanni* Wolosz. (after Frémy); 11. *O. splendida* Grev. (after Frémy); 12. *O. amoena* Gom. (after Frémy); 13. *O. acuminata* Gom. (after Frémy); 14. *O. animalis* Ag. (after Frémy); 15. *O. formosa* Bory (after Frémy); 16. *O. corallinae* (Kütz.) Gom. (after Gomont); 17. *O. miniata* (Zanard.) Hauck (after Frémy); 18. *O. foreaui* Frémy (after Frémy); 19. *O. minnesotensis* Tilden (after Tilden).

attenuated and bent; cells nearly quadrate, 4.7–6.5 μ long, at the ends up to 10 μ long, obtuse, not capitate, calyptra absent.

Plankton, Madras Coast (Iyengar and Desikachary, 1944, 55).

### 18. **Oscillatoria subtilissima** Kütz.

Tab. Phycologicae, 1: pl. 38, fig. 7, 1846; Forti in De Toni, Sylloge Algarum, 5: 171, 1907; Geitler, Kryptogamenflora, 950, 1932.

Trichome single or a few together, seldom forming a thallus, yellowish green, 1–1.5μ broad, straight or curved, septa indistinct, without gas-vacuoles.

Planktonic in brackish water and fresh water ponds and lakes in Ceylon (Crow, 1923b, 141); in filter beds, Berhampur in Orissa and in slimy patches on roadways (Bruhl and Biswas, 1922a, 3; Banerji, 1938, 101).

This species is not well known (*see* Geitler, 1932, 950; also Crow, 1923b, 141). Geitler gives an elaborated description of the species based on a material from near Vienna. The forms of this species recorded from India differ from Geitler's description in that the trichomes are not spirally coiled.

### 19. **Oscillatoria chilkensis** Biswas

The Algal flora of the Chilka lake, Mem. Asiatic Soc. Bengal, 11: 186, pl. 28, fig. 1, 1932.

Pl. 39, Fig. 1

Trichomes 4 μ diam., somewhat curved, slightly constricted at the joints, apex of the trichomes very shortly tapering, very rarely undulated, not hooked; apical cell obtusely rounded, not pointed or capitate, calyptra none; cells shorter than the diameter, about 2 μ in length, transverse walls not granulated, cell-contents homogeneous, pale blue-green.

Chilka lake, Orissa (Biswas, *loc. cit.*).

### 20. **Oscillatoria chlorina** Kütz. ex Gomont

Kützing, Phyc. gene., 185, 1843; Gomont, Monogr. Oscillariées, 223, 1892; Forti in De Toni, Sylloge Algarum, 5: 172, 1907; Frémy, Myxo. d'Afr. équat. franc., 215, fig. 183, 1929; Geitler, Kryptogamenflora, 951, fig. 611c, 1932.

= *Oscillatoria tenuis* Ag. var. *chlorina* (Kütz.) Playfair, Biol. of Richmond River, 132, pl. 6, fig. 10, 1914.

Pl. 40, Fig. 4

Thallus very thin, yellowish green; trichome straight or curved, unconstricted or slightly constricted at the cross-walls; 3.5–4 μ broad, sometimes up to 6 μ broad, gas-vacuoles absent; cells somewhat longer or shorter than broad, 3.7–8 μ long, cross-walls not granulated; calyptra absent.

Planktonic in a number of lakes, backwaters, or lagoons in Ceylon (Crow, 1923b, 141); in Loktak lake and on soil, Shillong in Assam (Bruhl and Biswas, 1926, 264; Parukutty, 1939, 234); in filter tanks, Khuroobhag, and in Yamuna at Allahabad (Gupta, 1956, 78); on *Trapa bispinosa*, Kamayut in Burma (Skuja, 1949, 46).

The trichomes in the Indian algae are 3–4 μ broad.

### 21. **Oscillatoria grunowiana** Gomont

Monogr. Oscillariées, 235, 1892; Forti in De Toni, Sylloge Algarum, **5**: 189, 1907; Geitler, Kryptogamenflora, 953, 1932.

Thallus dull green; trichome mostly very lightly spirally coiled, but also straight or irregularly bent, 3.5–6 μ broad, apices not attenuated, or slightly attenuated, slightly capitate; cells 1/3 as long as broad, or nearly as long, 1.4–4 μ long, often granulated at the cross-walls; end cell rounded without a calyptra.

Type not recorded.

Drouet (Amer. J. Bot., 24: 608, 1937) includes *O. articulata* under this species.

### Var. **articulata** (Gardner) Drouet

Brazilian Myxophyceae I, Amer. J. Bot., 24: 608, fig. 5, 1937.

= *O. articulata* Gardner, Mem. New York bot. Gard., 7: 34, pl. 7, fig. 64, 1927; Geitler, Kryptogamenflora, 963, fig. 614, 1932.

Trichome single or forming a thallus, 2.8–3.2 μ broad, straight or in a coil, not tapering at the apex, unconstricted at the cross-walls; cells 1/2–1/3, rarely longer, as long as broad, septa thick, end cell rounded without a thickened membrane.

In a pond, Berhampur in Orissa (Rao, C. B., 1938b, 166). The trichome in the Orissa material are 3–3.5 μ broad and its cells are 2–3.7 μ long.

Parukutty (1940, 121) describes a f. *tenuis* (under *O. articulata*) which is characterised by narrower trichomes (1.6–2.4 μ) and shorter cells (1.3–1.6 μ).

### 22. **Oscillatoria martini** Frémy

Myxo. d'Afr. équat. franc., 230, fig. 203, 1929; Geitler, Kryptogamenflora, 935, fig. 605b, 1932.

Pl. 38, Fig. 6

Trichome single amidst other algae, sparse, loosely and irregularly spirally coiled throughout its length, unconstricted at the cross-walls, 6 μ broad, at the ends short and clearly attenuated, ends straight or slightly curved, capitate;

cells 1/3 as long as broad or as long as broad, 2–3 (–6) μ long, not granulated at the cross-walls; end cells with flat convex distinctly thick and broad outer membrane.

On the moist edges of a pond, Delhi (Rao, C. S., 1940, 129).

The trichomes in the Delhi material were 5.5–6 μ and cells were 1.6–1.8 μ long.

Rao, C. B. (1938b, 166) reported from Berhampore, Orissa, a narrower form (4.5–5 μ broad) with cells 2–4 μ long.

### 23. **Oscillatoria willei** Gardner em. Drouet

Brazilian Myxophyceae I, Amer. J. Bot., 24: 606, fig. 4, 1937.

= *O. willei* Gardner, Mem. N. Y. bot. Gard., 7: 86, pl. 7, fig. 67, 1927; Geitler, Kryptogamenflora, 954, fig. 606b, 1932.

incl. *O. homogenea* Frémy, Myxo. d'Afr. équat. franc., 215, fig. 184, 1929; Geitler, Kryptogamenflora, 967, fig. 611d, 1932.

Pl. 38, Figs. 4, 5 & Pl. 40, Fig. 5

Trichome pale blue-green to grey blue-green, bent at the ends or screw-like, 2.4–3.6 μ broad, unconstricted at the cross-walls, ends not attenuated, not capitate; cells 1.3 up to twice as long as broad, not granulated at the cross-walls, and cell rounded without a thickened membrane.

On wet soil, Mussorie in U. P. (Rao, C. B., 1937b, 367); in a pond, Berhampore, Orissa (Rao, C. B., 1938b, 167) and in a tank at Calcutta (Banerji, 1938, 102).

Drouet has correctly included *O. homogenea* under *O. willei.*

### 24. **Oscillatoria terebriformis** Ag. ex Gomont

Agardh, Aufzahlung, Flora, 10: 634, 1827; Gomont, Monogr. Oscillariées, 234, pl. 7, fig. 24, 1892; Forti in De Toni, Sylloge Algarum, 5: 189, 1907; Geitler, Kryptogamenflora, 954, fig. 607d, 1932.

Pl. 38, Fig. 16

Thallus dull blue; trichomes end bent in a screw-like manner, and slightly attenuated, unconstricted at the cross-walls 4–6.5 μ broad, 2.5–6 μ long; end cell rounded, not capitate, calyptra absent.

Forming a green scum in stagnant waters, Lahore (Ghose, 1919, 10); in a pool at Companygunj, Assam (Biswas, 1934, 11), on a rocky dam near canal source, Latif Shah near Benaras (Rao, C. B., 1936, 171), in a waste water drain, Khurda Road, Orissa (Rao, C. B., 1938b, 166), on the ridge, New Delhi (Rao, C. S., 1940, 130), on moist soil, Benaras, Basti, Gorakhpur and Mirzapur (Singh, R. N., 1939a, 59) and Patna (Rao, C. S., 1939, 148).

Rao, C. S., (1939, 148) reported the trichomes as 3.3–4 μ broad.

Rao, (Myxo. of the United Provinces II, Proc. Indian Acad. Sci., B, 3: 171, 1936.) describes a form.

Trichomes 4–6.5 μ broad, cell 2.5–5 μ long, trichome ends bent, not twisted, old trichomes constricted at the cross-walls.

On submerged stones, Benaras (Rao, C. B., 1936, 171), Puri (Rao, C. B., 1938b 166); on soil and later free-floating, Narsapur (Rao, C. B., 1938a, 95), Palade, Travancore (Parukutty, 1940, 121); on submerged dead leaves in Tatahil, Barpathar and Sibsagar, Assam (Parukutty, 1939, 234), on moist ground near River Ravi Cambal State, Punjab Singh, V. P., 1941, 251).

V. P. Singh (*loc. cit.*) described the trichomes in the Punjab material as 5.7–7.6 μ broad.

### 25. **Oscillatoria boryana** Bory ex Gomont

Bory, Dict. class. d'hist. nat., 12: 465, 1827; Gomont, Monogr. Oscillariées, 234: pl. 7, fig. 22–23, 1892; Forti in De Toni, Sylloge Algarum, 5: 188, 1907; Frémy, Myxo. d'Afr. équat. franc., 227, fig. 201, 1929; Geitler, Kryptogamenflora, 954, fig. 607, 1932.

Pl. 38, Fig. 12

Trichome coiled screw-like either fully or only at the apices, sometimes straight, constricted at the cross-walls, 6–8 μ broad, sometimes lightly granulated at the cross-walls; cells 4–6 μ long; end cells rounded or more or less pointed, not capitate; calyptra absent.

In a waste-water drain, Khurda Road and Berhampur in Orissa (Rao, C. B., 1938b, 166), on rocks in a river near Vattiyoorkavu in Travancore (Parukutty, 1940, 121) on moist soil, Patna (Rao, C. S., 1939, 149) and Delhi (Rao, C. S., 1940, 130).

The breadth of the trichome varies very much in the Indian material; 3.3–5 μ (Parukutty), 4–6.6 μ (Rao, C. S.), 5–7 μ (Rao, C. B.) and 6–8 μ (Rao, C. S.).

### 26. **Oscillatoria chalybea** (Mertens) Gomont

Mertens in Jürgens, Alg. aquaticae, Decas., 12, nr. 4, 1822; Gomont, Monogr. Oscillariées, 232, pl. 7, fig. 19, 1892; Frémy, Myxo. d'Afr. équat. franc., 224, fig. 196, 1929; Forti in De Toni, Sylloge Algarum, 5: 185, 1907; Geitler, Kryptogamenflora, 956, fig. 608b, 1932; Frémy, Cyano. cotes d'Eur., 127, 1933.

incl. *Oscillatoria subsalsa* Ag., Sp. Alg., 66, 1925.

Pl. 38, Fig. 3

Thallus dark blue-green; trichome straight or lightly or irregularly spirally coiled, slightly constricted at the cross-walls, attenuated at the spex, and somewhat bent, 8–13 μ broad, blue-green; cells 1/2–1/3 times as long as broad, rarely as long as broad, 3.6–8 μ long, septa not granulated, end cell obtuse, not capitate, without calyptra.

Ceylon (Ferguson's colln. ex Gomont, 1893b, 234); in a pond at Setapak, Malaya (Biswas, 1929, 409); in salt lakes, tanks, rainwater puddles, drains, rice fields.—Calcutta (Biswas, 1926, 22), Narsapur in Andhra (Rao, C. B., 1938a, 91), Berhampur in Orissa (Rao, C. B., 1938b, 166), Kannukunji in Travancore (Parukutty, 1940, 120), Bombay (Gonzalves and Joshi, 1946, 176) on moist Mussorie (Rao, C. B., 1937b, 366), Narsapur (Rao, C. B., 1938a, 91), Delhi (Rao, C. S., 1940, 128).

In India the species is highly variable.—breadth of trichome 6.6–13 μ, 7–9.6 μ, 7.2–8.5 μ, 7–8 μ, the cells (2–) 3–6.6 μ long.

### Var. **insularis** Gardner

New Myxophyceae from Porto Rico, Mem. N.Y. bot. Gdn., 7: 36, pl. 7, fig. 6–8, 1927; Geitler, Kryptogamenflora, 956, fig. 606c, 1932.

Pl. 38, Fig. 18

Trichome ends bent and sickle-shaped, 6.4–7.2 μ broad, as long as or shorter than broad, not constricted at the cross-walls.

In a drain, Trivandrum (Parukutty, 1940, 128).

### 27. **Oscillatoria foreaui** Frémy

Cyanophycées de l'Inde Meridionale, Blumea, Suppl. II, Jubilee Vol., p. 23, fig. 2, 1942.

Pl. 40, Fig. 18

Trichomes sparse, elongate, bent or suberect, apex gently curved, subfalsiform, distinctly constricted at the cross-walls, and more or less torulose, 3 μ broad, apex not attenuated not capitate; cells 1/2 as long as broad, protoplasm granular, septa commonly inconspicuous, apical cell obtuse conical, calyptra absent.

In between filaments of *Tolypothrix tenuis* in stagnant water, Shembaganur, (Frémy, *loc. cit.*).

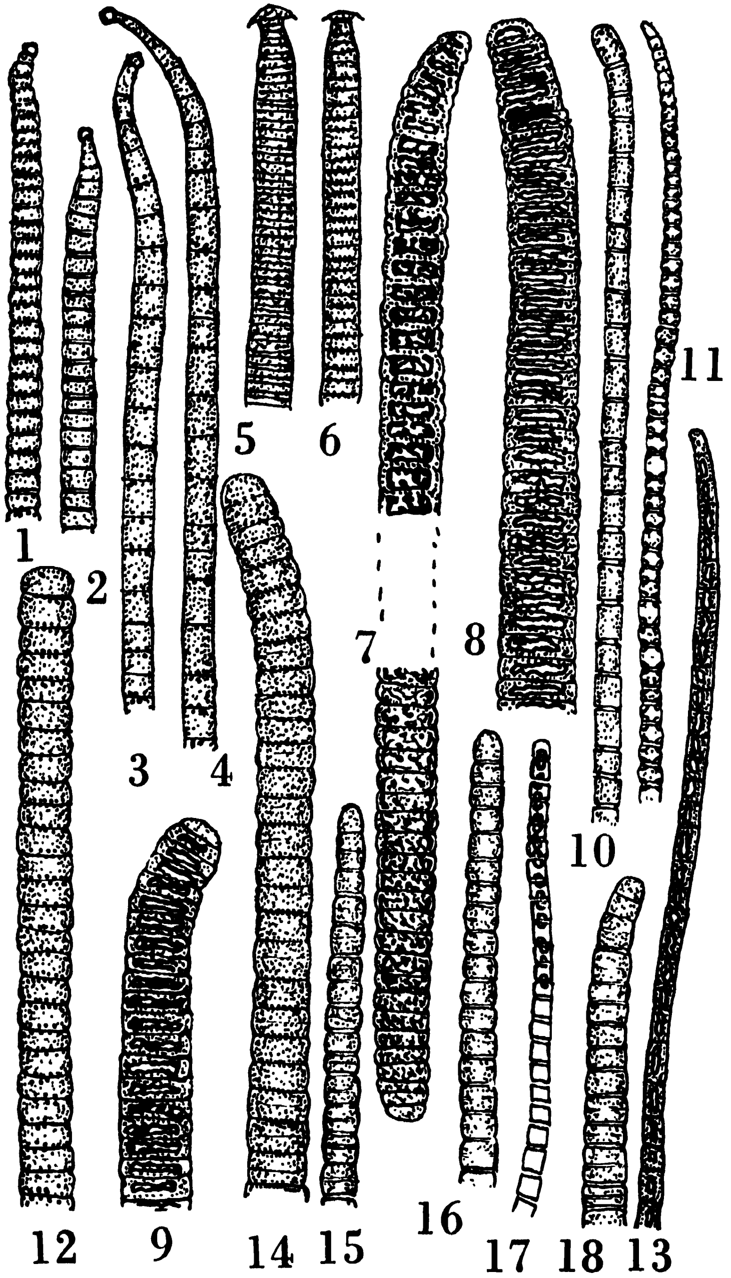

PLATE 41, Figs. 1–18.

1–4. *O. amoena* Gom. (after Skuja); 5–6. *O. anguina* forma (after Skuja); 7. *O. perornata* f. *attenuata* Skuja (after Skuja); 8, 9, 14. *O. perornata* Skuja (after Skuja); 10. *O. pseudogeminata* Schmid (after Skuja); 11. *O. schultzii* Lemm. (after Skuja); 12. *O. ornata* var. *crassa* Rao, C. B. (after Rao, C. B.); 13. *O. trichoides* Szafer (after Skuja); 15, 16, 18. *O. proteus* Skuja (after Skuja); 17. *O. pseudogeminata* v. *unigranulata* Biswas (after Skuja).

### 28. **Oscillatoria corallinae** (Kütz.) Gomont

Monogr. Oscillariées, 218, pl. 6, fig. 21, 1893; Forti in De Toni, Sylloge Algarum, 5: 162, 1907; Geitler, Kryptogamenflora, 955, 1932; Frémy, Cyano. cotes d'Eur., 121, pl. 30, fig. 9, 1933.

= *Leibleinia corallinae* Kütz., Sp. Alg., 276, 1849.

Pl. 40, Fig. 16

Trichome 6–10 μ broad, constricted at the cross-walls, slightly bent or curved at the ends, a little attenuated; cells 1/2–1/3 as long as broad, 2.7–4 μ long, not granulated at the cross-walls; end cells slightly capitate, with a convex slightly thickened membrane.

At Galle, Ceylon (Boergesen, 1936, 60).

### 29. **Oscillatoria proteus** Skuja

Zur Süsswasseralgenflora Burmas, Nov. Acta Reg. Soc. Upsal., ser. IV, 14: 48, pl. 8, figs. 11–13, 1949.

Pl. 41, Figs. 15, 16, 18

Trichomes amidst other planktonic algae, more or less straight, sometimes curved, apices briefly attenuated and slightly bent or curved, 6–7 μ broad, well constricted at the cross-walls, dissepiments visible, commonly granulated; cells 1/2–1/3–1/5 times as long as broad, 2–3.7 μ long, contents pale olivaceous or blue-green; apical cell hemispherical to rounded conical.

Free-floating in Rangoon and Kamayut in Burma (Skuja, *loc. cit.*).

### 30. **Oscillatoria decolorata** West, G. S.

Alg. Flora of Cambridgeshire, J. Bot., Lond., 33, 1899; Forti in De Toni, Sylloge Algarum, 5: 153, 1907; Geitler, Kryptogamenflora, 958, 1932.

Trichome single, nearly straight, short, indistinctly coloured, 12–13 μ broad, not attenuated, not capitate, end cell hemispherical, cells somewhat shorter than broad, not constricted at the cross-walls, with reticulate contents.

In a pond at Bai-ka-Bag, Allahabad (Gupta, 1956, 78).

Geitler (1932, 958) questions whether this species is not identical with *O. borneti* Zukal. Both *O. borneti* and *O. decolorata* have not been recorded earlier from India. Gupta who records *O. decolorata* has merely commented that the trichomes are narrower ( ? ) in the Indian material.

### 31. **Oscillatoria jasorvensis** Vouk.

Jugosl. Akad. Zagreb, 14: 133, fig. 1, 1919; Geitler, Kryptogamenflora, 962, fig. 613, 1932.

Thallus pale blue-green, yellowish green, straight, 2.5–8 μ broad, bent at the ends, not attenuated, not capitate; cells as long as broad or nearly so; end cells rounded, without calyptra.

In running soiled trench water, Rangoon (Skuja, 1949, 46).

Gonzalves, (The Algal flora of the hot springs of Vajreshwari near Bombay, J. Univ. Bombay, 16: 26, 1947) describes a form.

Trichome 4–4.4 μ; cells 2.4–3.2 μ long.

In hot springs (40–49°C) at Vajreshwari (Gonzalves, *loc. cit.*).

### 32. **Oscillatoria mougeotii** Kütz.

Tab. Phycologicae, 1: 30, pl. 41, fig. 10, 1849; Forti in De Toni, Sylloge Algarum, 5: 149, 1907; Geitler, Kryptogamenflora, 958, 1932. *non* Stizenb.

Thallus dull blue-green, at first attached, later free-swimming; trichomes straight, or somewhat bent, constricted at the cross-walls, 5.5–7.5 μ broad, not attenuated, end cell broadly rounded.

Plankton in tanks, Balaluwewa and Walikulam near Kekirawa, Ceylon (Crow, 1923b, 141).

### 33. **Oscillatoria tenuis** Ag. ex Gomont

Agardh, Alg. Dec. 2: 25, 1813; Gomont, Monogr. Oscillariées, 220, pl. 7, figs. 2–3, 1892; Forti in De Toni, Sylloge Algarum, 5: 166, 1907; Frémy, Myxo. d'Afr. equat. franc., 217, fig. 186, 1929; Geitler, Kryptogamenflora, 959, fig. 611f–g, 1932; Frémy, Cyano, cotes d'Eur., 121, pl. 30, fig. 10, 1933.

incl. *O. viridis* Vaucher, Hist. conf. d'eau douce, 195, pl. 15, fig. 7, 1803.

Pl. 42, Fig. 15

Thallus thin blue-green or olive-green, slimy; trichome straight, fragile slightly constricted at the cross-walls, 4–10 μ broad, blue-green, sometimes bent at the ends, not attenuated at the apices, not capitate; cells up to $\frac{1}{3}$ as long as broad, 2.6–5 μ long, at the septa mostly granulated; end cell more or less hemispherical with thickened outer membrane.

In freshwater ponds, tanks, shallow pools, rainwater puddles, springs, straggling portions of river, in salt lakes, on moist soil and on barks of trees.—Calcutta (Martens, 1870b, 259; Prain, 1905, 333; Biswas, 1925, 4; 1926, 19; 1942, 196/199; Banerji, 1938, 102), Faridpur (Bruhl and Biswas, 1922a, 6), Berhampur (Bruhl and Biswas, 1922a, 6; Rao, C. B., 1938b, 166), Chinsurah (Bruhl and Biswas, 1922a, 6), Loktak lake (Bruhl and Biswas, 1926, 263), Hyderabad (Ghousuddin, 1936, 150), Benaras (Rao, C. B., 1937b, 366), Dharbhanga and Madhubani in Bihar (Rao, C. B., 1939, 148, 149), Delhi (Rao, C. S., 1940, 130), Shembaganur in Madras (Frémy, 1942, 21), Bombay

(Gonzalves and Joshi, 1946, 176) in India; Arracan, Akyab (Martens, 1871b, 462; Theobald, 1883, 24) in springs in river banks, Bhamo (West and West, 1907, 241) and Rangoon (Ghose, 1927e, 80; Skuja, 1949, 49) in Burma; Pandure (West and West, 1902, 204), Anuradhapura, Trincomalee, Haberane, Peradiniya (Crow, 1923b, 141), and Gregory lake (Holsinger, 1954, 9) in Ceylon; Lahore in Pakistan (Ghose, 1919, 9; 1924, 338; Singh, H. D., 1933, 106).

The diam. of the trichome in the Indian specimens is varying, 4–8 μ, 4.5–6.6 μ, 5–9 μ, 5–6 μ, 5–6.6 μ, 6–7 μ, 8–10 μ, 9 μ and only in two instances the breadth has been given as 4–11 μ and 4–12 μ. Thus the separation of the varieties especially var. *natans* and var. *tergestina* (Geitler, 1932, 959) on the basis of the diameter of the trichome alone appears to be not very satisfactory. In fact Crow (1923b, 14) includes var. *natans* under the type itself. Var. *tergestina* Rabenh. (Fl. Eur. Alg., 102, 1865; Frémy, Myxo. d'Afr. équat. franc., 217, 1929; Geitler, Kryptogamenflora, 959, 1932)—trichome 4–6 μ broad, the rest as in the type, (Pl. 42, Figs. 13, 14)—has been reported from a stagnant pond near railway station, Kamayut in Burma (Skuja, 1949, 49).

### 34. **Oscillatoria nigra** Vaucher

Hist. Conf. 192, pl. 15, fig. 4, 1803; Forti in De Toni, Sylloge Algarum, 5: 164, 1907; Geitler, Kryptogamenflora, 960, 1932.

Thallus more or less leathery, often free-swimming, olive or dark-brown or blackish, glistening; trichomes straight or more or less bent, 8.5 μ (6–9 (–10) μ broad), ends round and truncated, cells as long as broad or up to $\frac{1}{3}$ as long as broad, septa granulated, slightly constricted.

Freshwater algae, Bengal (Turner, 1892, 13).

### 35. **Oscillatoria raoi** De Toni, J.

Diagnoses Algarum novarum, I, cent. 6: 560, 1939.

= *Oscillatoria variabilis* Rao, Myxophyceae of the United Provinces II, Proc. Indian Acad. Sci., B, 3: 172, fig. 3A-D, 1936, *non Oscillaria variabilis* Desvaux, 1865.

Pl. 42, Figs. 16–19

Plant mass thin, membranous, firm, pale blue-green to pale bluish violet; trichome straight, usually of uniform thickness, and only rarely slightly tapering at the ends, without constrictions at the joints, 5.2–6 μ broad, septa indistinct, but with distinct granules closely arranged on either side; cells 2.5–6 μ (average 5 μ) long, with homogeneous contents, end cells rounded rarely conical, sometimes with constrictions at the septum, not capitate, without any calyptra.

Planktonic with other algae in a rainwater pool, Benaras (Rao, C. B., *loc. cit.*), on stones near house outlet, Puri in Orissa (Rao, C. B., 1938b, 167), on submerged stones in a stream at Cherrapunji, Assam (Parukutty, 1939, 234), and on moist soil, Delhi (Rao, C. S., 1940, 130).

Rao, C. B., (The Myxophyceae of the Orissa Province I, Proc. Indian Acad. Sci., B, 8: 167, 1938b) describes a form—Trichomes 5–5.5 μ broad, cells 2.8–45 μ long, Trichomes tapering at the extreme apices, the end cells with outer walls thickened.—from moist soil near water pipe in Berhampur (Rao, C. B., *loc. cit.*).

Singh, R. N. (Algal flora of paddy-field soils of the United Provinces I, Indian J. Agric. Sci., 9: 60, 1939) describes a form of *O. variabilis* Rao, C. B.—Trichomes 6.2–6.6 μ broad; cells 3–3.3 μ long, apical cells rounded.—In cultures of paddy-field soils from Mirzapur, Basti, Gorakhpur and Benaras Districts.

### 36. **Oscillatoria simplicissima** Gomont

Monogr. Oscillariées, 219, pl. 7, fig. 1, 1892; Forti in De Toni, Sylloge Algarum, 5: 165, 1907; Geitler, Kryptogamenflora, 961, 1932.

Thallus dark blue-green; trichome straight, not constricted at the cross-walls, yellowish blue-green, 8–9 μ broad, not attenuated at the apices, not capitate; cells $\frac{1}{4}$–$\frac{1}{2}$ as long as broad, 2–4 μ long, septa not granulated, end cells hemispherical, with or without a slightly thickened membrane.

In salt lakes, Calcutta (Biswas, 1926, 19); planktonic in Beira and Gregory lakes in Ceylon (Holsinger, 1954, p. 9).

Holsinger (1954) reports a forma of this species but does not give any description or comment.

### 37. **Oscillatoria irrigua** (Kütz.) Gomont

Monogr. Oscillariées, 218, pl. 6, figs. 22–23, 1892; Forti in De Toni, Sylloge Algarum, 5: 163, 1907; Frémy, Myxo. d'Afr. équat. franc., 214, fig. 182, 1929.

= *Oscillaria irrigua* Kütz., Phyc. gene, 189, 1843; Tab. Phycologicae, 1: 30, pl. 42, fig. IV, 1849.

Pl. 42, Figs. 7, 9

Thallus blackish blue-green, trichome light bluish purple, when dried hyaline or pale blue, straight, flexuous, not torulose, 6–11 μ broad, apex, slightly attenuated, subcapitate, straight; cells quadrate to $\frac{1}{2}$ as long as broad, 4–11 μ long, contents in dried specimen, pellucid, granular; septa ordinarily not granulated; apical cell convex, with an evident thickened outer wall.

On moist soil—India near Bombay (West ex Forti, 1907, 163); Plankton near West Hill, and Gulf of Mannar (Devanesan 1942, 142), and in soils, Lahore (Singh, H. D., 1933, 106).

### 38. **Oscillatoria fremyii** De Toni, J.

Noterelle di nomenclatura algologica, 1: 7, 1934.

= *O. neglecta* Lemmermann, Kryptogamenflora der Mark Brandenburg, 3: 112, 1910; Geitler, Kryptogamenflora, 963, 1932. *non* Wood, 1872.

Thallus bright blue-green; trichome more or less straight, constricted at the cross-walls, 1–1.3 µ broad, pale blue-green; cells 1–2 times longer than broad, 1–2 µ long, septa not granulated; end cell rounded.

On the University estate, Rangoon in Burma (Skuja, 1949, 46); in a roadside channel, Keli valley near Aravankadu ( ! ).

### 39. **Oscillatoria gloiophila** Grun.

in Rabenhorst, Fl. Eur. Alg., 2: 98, 1865; Forti in De Toni, Sylloge Algarum, 5: 173, 1907.

Trichome circinate, variously flexuous, 3.7–4.5 µ broad, now and then with an indistinct sheath, cells as long as broad, with more or less evident two series of granules, subtorulose.

In a tank at Bandra, Bombay (Gonzalves and Joshi, 1946, 168).

### 40. **Oscillatoria minnesotensis** Tilden

Amer. Alg., Cent. 6, no. 596, 1902; Minnesota Algae, Myxo., 75, pl. 4, fig. 21, 1910.

Pl. 40, Fig. 19

Thallus thin, dark blue-green; trichome 2–5 µ broad, more or less curved, especially constricted at the joints, apex of the trichome straight, or slightly bent, neither tapering nor capitate; apical cell rotund, calyptra none; cells 2–4 µ in length, transverse walls pellucid, cell contents homogeneous.

In salt lakes, Calcutta (Biswas, 1926, 20).

Drouet (Studies on Myxo. I, Amer. J. Bot., 29: 136, 1942) places this in *Phormidium* as *P. minnesotensis* (Tilden) Drouet. Tilden (1910, 75) first doubted that this might be *Phormidium* but later convinces herself that it is an *Oscillatoria.*

### 41. **Oscillatoria hamelii** Frémy

Myxo. d'Afr. équat. franc., 218, fig. 187, 1929; Geitler, Kryptogamenflora, 964, fig. 611h, 1932.

Trichome single, amidst other algae, flexible, more or less bent or undulate, slightly constricted at the cross-walls, 4.8–5 µ broad, at the ends little attenuated, not capitate; cells mostly 1½ times as long as broad, 7.2–8 µ long, not granulated at the cross-walls, end cells rounded, calyptra absent.

In a pond at Chittavaram, Andhra State (Rao, C. B., 1938a, 91).

Skuja (1949, 46) describes a form from Rangoon which has somewhat broad and relatively short cells.

### 42. **Oscillatoria limnetica** Lemm.

Beitrage zur Kenntnis der Planktonalgen X, Ber. dtsch. bot. Ges., 18: 310, 1900; Forti in De Toni, Sylloge Algarum, 5: 171, 1907; Frémy, Myxo. d'Afr. équat. franc., 220, fig. 189, 1929; Geitler, Kryptogamenflora, 963, fig. 611 and 612b, 1932; Frémy, Cyano. cotes d'Eur., 123, pl. 31, fig. 3, 1933.

= *O. splendida* var. *limnetica* (Lemm.) Playfair, Biol. Richmond River, 130, pl. 6, fig. 4, 1914.

Pl. 37, Fig. 3

Trichome straight or slightly bent, distinctly constricted at the cross-walls, pale blue-green, 1.5 μ broad, not attenuated, not capitate; cells $2\frac{1}{2}-6$ times as long as broad, 4–12 μ long; end cells rounded, calyptra absent.

Planktonic in Red Hills lake and in slow sand filters near Madras (Ganapati, 1940a, 241/246); in a slow flowing stream at Tirupati (!) and in a rainwater pool at Pudukkotah (!).

The Tirupati and Puddukkotah forms are 1.3–2 μ broad.

Prescott (1951, Algae of the Great Western lakes Area, Michigan, Cranbrook Institute of Science) records material with trichomes which are not constricted. Holsinger (1954, p. 17, fig. 4B) records a similar form from Beira lake, Nuwara Wewa tank and in Gregory lake, in Ceylon.— Trichome solitary, straight, or slightly curved, seldom more than 100 μ long, not tapering towards the apex; end cell bluntly rounded and without a calyptra; cells 1 μ broad, 2.5–7 μ long, not constricted at the septa which are clearly visible, but devoid of granules.

### 43. **Oscillatoria amphigranulata** van Goor

Zur Kenntnis der Oscillatoriaceen, Rec. trav. bot. néerland., 15: 255, pl. 2, fig. 2, 1918; Geitler, Kryptogamenflora, 964, 1932.

Pl. 37, Fig. 4

Trichome straight, distinctly constricted at the cross-walls, 1.75–2 μ broad, ends not attenuated, not capitate; cells 2.5–5 μ long, as long as broad or up to twice as long, with two gas-vacuoles at the septa, pale blue-green; end cell rounded, calyptra absent.

Plankton, Godavari River (!).

There is a single spherical sometimes elongated gas-vacuole on either side of the septum in the Godavari form.

### 44. **Oscillatoria angustissima** W. et G. S. West

Welwitsch's Afr. Freshw. Algae, J. Bot. Lond., 35: 300, 1897; Forti in De Toni, Sylloge Algarum, 5: 171, 1907; Frémy, Myxo. d'Afr. équat. franc., 217, 1929; Geitler, Kryptogamenflora, 965, 1932.

Thallus expanding, blue-green; trichome 0.6 μ broad, blue-green, bent, looped, ends not attenuated, not capitate, not constricted at the cross-walls; cells 1½–2 times longer than broad.

Rangoon (Skuja, 1949, 46).

### 45. **Oscillatoria angusta** Koppe

Die Schlammflora der östholsteinischen Seen und des Bodensees, Arch. Hydrobiol. (u. Planktonk.), 14: 641, 1923; Geitler, Kryptogamenflora, 965, 1932.

Trichome colorless, 0.8–1.2 μ broad, not constricted at the cross-walls, at the ends rounded, straight; cells 5–7 μ long, without gas-vacuoles.

In a beach pool at Madras ( ! ) and in a stream at Vaiyampatti ( !).

### 46. **Oscillatoria quadripunctulata** Bruhl et Biswas

Algae of Bengal Filter Beds, J. Dept. Sci., Calcutta Univ., 4: 5, pl. 1, fig. 6, 1922a; Geitler, Kryptogamenflora, 966, 1932.

Pl. 37, Fig. 5

Trichomes curved or nearly straight, closely associated into a delicate very pale greenish blue membrane, 1–1.5 μ in diam., cells 3.5–5 μ long, 2–4 times as long as wide, not constricted at the joints, contents minutely granular, transverse walls rather obscure marked by a pair of somewhat larger granules on either side.

In filter beds, in ponds, road slimes, temporary microphytoplankton of rivers, and on moist soil. — Pirojpur in Barisal Dist., and Calcutta in Bengal (Bruhl and Biswas, 1922a, 5; Biswas, 1925, 10; Banerji, 1938, 102; Biswas, 1942, 199), Benaras (Rao, C. B., 1937b, 366), Ellore in Andhra (Rao, C. B., 1938a, 91), Kodaikanal ( ! ) and Ampang in Malaya (Biswas, 1929, 410).

The diameter of the trichome varies from 1–1.8 μ generally. Biswas (1929, 410) describes the trichome as 2–3 μ broad in the Malayan alga. The Kodaikanal form agrees closely with the Malayan alga.

*O. quadripunctulata* agrees so closely with *O. amphibia* that it is difficult to distinguish it excepting by the dimensions of the alga. The Malayan alga appears to be the same as *O. amphibia* and not *O. quadripunctulata* excepting that it has four granules instead of two (cf. f. *unigranulata* Singh, R. N.).

Gardner (Madrono 28: 2, 1927) reports the occurrence of a delicate sheath and transfers the species to *Phormidium* as *P. quadripunctulatum* (B. and B.)

Gardner. As none of the subsequent records of the species in India mention of this character, this transfer is not accepted.

### Var. **unigranulata** Singh, R. N.

Myxophyceae of the United Provinces, IV, Proc. Indian Acad. Sci., B, 9: 68, fig. 1F, 1939a.

Trichome 1–1.7 μ broad, cells 7–8 μ long, septa with a single granule on either side.

In muddy water, Gorakhpur and in soils of Benaras, Basti, Gorakhpur and Mirzapur all in U. P. (Singh, R. N., *loc. cit.*; 1939b, 60).

### 47. **Oscillatoria trichoides** Szafer

Zur Kenntnis d. Schwefelfl. Umgeb. v. Lemberg, Azweig. Akad. Wiss. in Krakau, Math. Klasse: 161, pl. 6, fig. 2, 1910; Geitler, Kryptogamenflora, 950, 1932.

Pl. 41, Fig. 13

Trichome straight, not constricted at the cross-walls, 1–1.5 μ broad, yellow-green, cells up to 5 μ long with 1–2 small granules.

Not recorded.

Skuja (1949, pl. 8, fig. 23) described a variety ( ? ) from Rangoon which differs slightly from the type:

Filaments 1.2–1.4 μ broad, more or less straight to variously curved, ends not markedly tapering and not bent, little constricted at the cross-walls, cells mostly somewhat longer than broad, but shorter after division, 1–2.7 μ long, greenish yellow with central gas-vacuoles.

In a running soiled trench water, Rangoon, Burma (Skuja, *loc. cit.*).

### 48. **Oscillatoria pseudogeminata** G. Schmid

Ber. dtsch. bot. Ges., 32: 124, fig. 4, 1914; Geitler, Kryptogamenflora, 966, fig. 616, 1932.

Pl. 41, Fig. 10

Thallus pale or dirty blue-green, trichomes coiled, pale blue-green, ends not attenuated, 1.3–2.2 μ broad; cells as long as broad or somewhat longer or shorter than broad, about 2.6 μ long, not constricted at the cross-walls, cross-walls thick, not granulated, end cell rounded, calyptra absent.

Among other algae, on submerged stones, leaves etc., and on moist soil.—Campanyganj, Fatahil, Barpathar and Sibsagar in Assam (Biswas, 1934, 10; Parukutty, 1940, 120), Benaras (Rao, C. B., 1937b, 366), Cuttack in

Orissa (Rao, C. B., 1938b, 167), Madhubani in Bihar (Rao, C. S., 1939, 149) and Tampanur in Travancore (Parukutty, 1940, 120) in India; Rangoon in Burma (Skuja, 1949, 48).

Skuja's Rangoon form was 2–2.7 μ broad.

Rao, C. B. (1937b, 366) described a form wherein the trichomes are 1.6–2μ and possesses much longer cells (1.8–5 μ long).

### Var. **unigranulata** Biswas

Malayan aquatic Biology, J. Fed. Malay Stat. Mus., 14: 409, pl. 9, fig. 7, 1929; Geitler, Kryptogamenflora, 966, 1932.

Pl. 39, Fig. 19 & Pl. 41, Fig. 17

Trichomes 2–3 μ in diam., tenuous, straight or somewhat curved, not constricted at the cross-walls, not attenuated at the apices, obtusely rounded or truncate, not capitate; calyptra none; cells 2.5–4 μ in length; cell-wall thick, distinct with one large granule situated at the centre of the partition walls on either side; cell contents finely uniformly granular, blue-green.

In a pond, Setapak, Malaya (*loc. cit.*) and in a stagnant pond near Kamayut, Burma (Skuja, 1949, 49).

The trichomes in the Burmese alga are 2–2.7 μ in diam.

Rao, C. S. (1940, 128) describes a form of *O. pseudogeminata* from Delhi growing on moist soil. The trichomes in this form are 1.9–2.2 μ broad, and the cells are up to 3.5 μ long. The form is based on the presence of a granule on either side of the septa. The form appears to be same as var. *unigranulata* Biswas.

### 49. **Oscillatoria amphibia** Ag. ex Gomont

C. Ag., Aufzahlung etc., Flora, 10: 632, 1827; Gomont, Monogr. Oscillariées, 221, pl. 7, fig. 4–5, 1892; Forti in De Toni, Sylloge Algarum, 5: 169, 1907; Frémy, Myxo. d.Afr. équat. franc., 213, fig. 180, 1929; Geitler, Kryptogamonflora, 966, 1932. Frémy, Cyano. cotes d'Eur., 122, pl. 31, fig. 2, 1933.

Pl. 37, Fig. 6

Thallus deep blue green; trichome straight or coiled, apices not attenuated, not capitate, not constricted at the cross-walls, 2–3 (3.5) μ broad, pale blue-green; cells 2–3 times longer then broad, 4–8.5 μ long, with two granules at the septa, end cell not capitate, rounded, calyptra absent.

Planktonic in freshwater tanks, lakes, and ponds, in the straggling microphytoplankton of rivers, in salt lakes, on moist soil and on submerged objects.—Howrah (Martens, 1870b, 258; Prain, 1905, 332), filterbeds at Chinsura, Berhampur, Burdwan, Faridpur and Jessore (Brühl and Biswas, 1922a, 4), Road slimes, Calcutta (Biswas, 1925, 4), on soil and water plants in Calcutta (Banerji, 1938, 102), Calcutta salt lakes (Biswas, 1926, 20), Hooghly river (Biswas, 1942, 196/199), Loktak lake in Assam (Bruhl and Biswas, 1926, 264) and in a stream at Vaiyampatti near Tiruchirapalli ( ! ), Periyar reservoir ( ! ), rock pools near Jog falls ( ! ) and Yercaud lake ( ! ) in Madras state.

In a marsh at Mercara a form of this species was found which lacked granules at the septa. For the rest it agreed with the type.

### 50. **Oscillatoria geitleriana** Elenkin

Monogr. Alg. Cyano., pars spec., 2: 1288, 1949.

= *Oscillatoria geitleri* Frémy, Myxo. d'Afr. équat. franc., 216, fig. 185, 1929; Geitler, Kryptogamenflora, 967, fig. 611e, 1932; *non* Kisselev, 1927.

Pl. 40, Fig. 9

Trichome single, amidst other algae, long, flexible, blue-green, 2.5 μ broad, not constricted at the cross-walls, ends erect, not attenuated, subcapitate, cells 1½ times longer than broad, 3–3.5 μ long, septa not granulated; end cells with a convex distinctly thick membrane.

In paddy fields, Palode in Travancore (Parukutty, 1940, 121).

Parukutty gives the breadth of the trichome as 3.5–4.5 μ broad in the Travancore alga.

### 51. **Oscillatoria amoena** (Kütz.) Gomont

Monogr. Oscillariées, 225, pl. 7, fig. 9, 1892; Forti in De Toni, Sylloge Algarum, 5: 175, 1907; Frémy, Myxo. d'Afr. équat. franc., 220, fig. 190, 1929; Geitler, Kryptogamenflora, 969, fig. 603a, 611k, 1932.

Pl. 40, Fig. 12

Thallus more or less blue-green; trichomes straight, slightly constricted at the cross-walls, ends gradually attenuated, 2.5–5 μ broad, dull blue-green; cells nearly as long as broad, 2.5–4.2 μ long, septa granulated, end cells capitate, broadly conical with calyptra.

On moist grounds, in running soiled trench water.—Rangoon and its neighbourhood (Skuja, 1949, 46).

### Var. **non-granulata** Ghose

The Myxophyceae of Rangoon—III, J. Burma Res. Soc., 17: 240, pl. 2, fig. 7, 1927; Geitler, Kryptogamenflora, 969, 1932.

Pl. 39, Figs. 6, 7

Stratum more or less blue-green; trichome straight, flexible, not constricted at the cross-walls, occasionally constricted at the apices, 4–5 μ thick, cells quadrate, 3–4.2 μ long, cross-walls not-granulated, gradually attenuated at the apices, straight or slightly bent; end-cell globose, capitate with calyptra.

On exposed damp ground, Rangoon, Burma (Ghose, *loc. cit.*).

### 52. **Oscillatoria okeni** Ag. ex Gomont

Agardh, Aufzählung. etc., Flora, 10: 633, 1827; Gomont, Monogr. Oscillariées, 232, pl. 7, fig. 18, 1892; Forti in De Toni, Sylloge Algarum, 5: 185, 1907; Frémy, Myxo. d'Afr. équat. franc., 227, fig. 200, 1929; Geitler, Kryptogamenflora, 969, fig. 608a, 1932; Frémy, Cyano, cotes d'Eur., 127, pl. 31, fig. 13, 1933.

Pl. 38, Fig. 17

Thallus dull blue-green; trichome straight, fragile distinctly constricted at the cross-walls, 5.5–9 μ broad, at the ends gradually attenuated, undulating, slightly bent; cells 1/3 as long as broad, 2.7–4.5 μ long, at the ends up to 8 μ long; end cells obtuse or subconical not capitate, without calyptra.

In ponds, in drains, and on moist soil.—Benares (Rao, C. B., 1937b, 367), Berhampur and Puri in Orissa (Rao, C. B., 1938b, 167), Trivandrum (Parukutty, 1940, 121) and Delhi (Rao, C. S., 1940, 130).

### 53. **Oscillatoria claricentrosa** Gardner

New Myxophyceae from Porto Rico, Mem. N. Y., bot. Gdn., 7: 37, pl. 8, fig. 72, 1927; Geitler, Kryptogamenflora, 971, fig. 615c, 1932.

Pl. 40, Fig. 2

Trichome nearly straight, 2.3–2.5 μ broad, attenuated at the ends, pointed, slightly constricted at the joints, cells 3–5 times longer than broad, up to 11 μ mostly 6–8 μ long.

Madhubani, Bihar (Rao, C. S., 1939, 149).

### f. **bigranulata** Rao, C. B.

Myxophyceae of United Provinces, Proc. Indian Acad. Sci., B, 6: 367, fig. 7c, 1937b.

Pl. 39, Figs. 13, 14

Trichome 2–2.5 μ broad, cells 5–10 μ long, ends gradually tapering, septa with two granules on either side.

In a stagnant drain, Benaras (Rao, C. B., *loc. cit.*); in a rain water puddle, Chittavaram, Andhra State (Rao, C. B., 1938a, 92).

### 54. **Oscillatoria schultzii** Lemm.

Forschb. Biol. stat., Plön, 12: 145, pl. 4, figs. 14, 15, 1905; Geitler, Kryptogamenflora, 970, 1932.

Pl. 41, Fig. 11

Thallus dull-green to very dark; trichome straight or bent, distinctly constricted at the cross-walls gradually attenuated at the apices, straight or bent like a sickle, 2.6 μ broad, pale blue-green; cells nearly barrel-shaped as long as broad or somewhat longer seldom somewhat shorter than broad, 1.5–4 μ long, granulated at the cross-walls; end cell conical.

On mud or in cultures of paddy-field soils.—Rangoon in Burma (Skuja, 1949, 49); Thana in Bombay State (Gonzalves and Gangla, 1949, 53).

Skuja's form differs very much from the type. The trichome in the Rangoon alga is 2.5–3.5 μ broad and the septa has 2–3 granules on its either side.

### 55. **Oscillatoria formosa** Bory ex Gomont

Bory, Dict. class. d'hist. nat., 12: 474, 1827; Gomont, Monogr. Oscillariées, 230, pl. 7, fig. 16, 1892; Forti in De Toni, Sylloge Algarum, 5: 182, 1907; Frémy, Myxo. d'Afr. équat. franc., 225, fig. 197, 1929; Geitler, Kryptogamenflora, 970, fig. 619b, 1932; Frémy. Cyano. cotes d'Eur., 126, pl. 31, fig. 11, 1933.

Pl. 40, Fig. 15

Thallus blue-green; trichome straight, slightly constricted at the cross-walls, 4–6 μ broad, bright blue-green, attenuated at the ends and bent; cells nearly quadrate, up to 1/2 as long as broad, 2.5–5 μ long, septa sometimes slightly granulated; end-cells nearly obtuse, calyptra absent, not capitate.

In tanks, ponds, filter beds, waste-water drains, in salt lakes, in microphytoplankton of rivers, on water-logged soils, on submerged objects, on moist soils and rocks.—Calcutta (Martens, 1870b, 259; Biswas, 1926, 21; 1942, 199), Chinsura in Bengal (Bruhl and Biswas, 1922a, 6), Bombay (Schmidle, 1900b, 162; Dixit, 1936, 103), Mussorie, Benaras (Rao, C. B., 1937b, 367), Allahabad (Gupta, 1956, 78), Palacol and Polamur in Andhra (Rao, C. B., 1938a, 91), Shembaganur in Madras State (Frémy, 1942, 21), Cuttack (Rao, C. B., 1938b, 167), Dharbanga in Bihar (Rao, C. S., 1939, 149), Pangode in Travancore (Parukutty, 1940, 121), Delhi (Rao, C. S., 1940, 129); Myingon, Kyauktan and Rangoon in Burma (Skuja, 1949, 46).

Rao, C. B. (1938a, 92) describes a form from Narasapur in Andhra Pradesh — on moist soil — which has shorter cells (3.8–4.8 μ broad and 1–2.4 μ long).

### f. **loktakensis** Bruhl and Biswas

Algae of the Loktak Lake, Mem. Asiatic Soc. Bengal, n.s., 8: 264, pl. 1, fig. 5, 1926.

Pl. 39, Fig. 4

Trichomes among other algae, 4–5 μ broad, straight or bent, flexible, constricated at the cross-walls, ends slightly attenuated, capitate; cells 2.5–3 μ long, shorter than long, septa prominent, contents granular, blue-green.

Loktak lake, Assam (Bruhl and Biswas, *loc. cit.*).

### 56. **Oscillatoria cortiana** Meneghini ex Gomont

Meneghini, Conspectus algologiae euganese, 8, 1837; Gomont, Monogr. Oscillariées, 231, pl. 7, fig. 17, 1892; Forti in De Toni, Sylloge Algarum, 5: 182, 1907; Frémy, Myxo. d.Afr. équat. franc., 227, fig. 199, 1929; Geitler, Kryptogamenflora, 971, fig. 619c, 1932.

Pl. 38, Fig. 14

Thallus dull blue-green; trichome straight, slightly constricted at the joints, 5.5–8 μ broad, gradually tapering at the ends, bent, not capitate, blue-green; cells as long as broad or longer or shorter than broad, 5.4–8.2 μ long, at the ends up to 14 μ long, septa not granulated; end cell obtuse, without calyptra.

In ponds, pools — on water plants, Bengal (Martens, 1870b, 258; Prain, 1905, 330), on the edges of ponds, Delhi (Rao, C. S., 1940, 129), in pools on the way to waterfalls, Courtallam ( ! ) and in a slow flowing streams, Tirupati ( ! ); Tank Balaluwewa, Ceylon (Crow, 1923b, 141).

Rao's specimens appear to be smaller than the type (cells 3.5–3.8 μ broad and 2–2.8 μ long). The South Indian specimens are also similarly narrower (3.9–5.6 μ broad). These resemble more closely *O. cortiana* recorded from Japan by Yoneda (1938).

### 57. **Oscillatoria tanganyikae** G. S. West

Rep. Freshw. Algae incl. Phytoplankton of the Third Tanganyika Exped., J. Linn. Soc. Bot., 38: 177, pl. 9, fig. 9, 1907; Frémy, Myxo. d'Afr. équat. franc., 224, fig. 198, 1929; Geitler, Kryptogamenflora, 971, fig. 618c-f. 1932.

Pl. 40, Figs. 6-8

Trichome single, free-swimming, olive-green, straight or nearly straight, at the ends gradually tapering, and bent, sometimes not bent, rounded or obtuse rounded, constricted at the cross-walls; cells quadrate, 10–12 μ, at the ends 6 μ, mostly somewhat shorter than broad, 6–10 μ long, at the ends up to twice as long as broad; cell contents finely granuler, prominently refractive granules; end cell rounded, often bent, calyptra absent.

Slow sand filters, Madras (Ganapati, 1940a, 246).

### 58. **Oscillatoria splendida** Grev. ex Gomont

Greville, Flora Edinensis, 305, 1824; Gomont, Monogr. Oscillariées, 224, pl. 7, figs. 7, 8, 1892; Forti in De Toni, Sylloge Algarum, 5: 173, 1907; Frémy, Myxo. d'Afr. équat. franc., 220, fig. 191, 1929; Geitler, Kryptogamenflora, 972, fig. 611 m-o, 620d-f, 1932. Frémy, Cyano. cotes d'Eur., 123, 1933.

Pl. 37, Figs. 7 and 8, Pl. 38, Fig. 10 & Pl. 40, Fig. 11

Thallus brilliant blue-green or olive-green; trichome straight or curved, not constricted at the cross-walls, at the ends gradually attenuated, 2–3 μ broad; cells 2–4 times longer than broad rarely quadrate, 3–9 μ long, septa often granulated; ends more or less bent, sometimes screw-like or a sickle; end cells capitate, nearly rounded, mostly without calyptra.

Planktonic or on submerged objects. — Palta waterworks, Jadavpur and River Hoogly near Calcutta (Bruhl and Biswas, 1922a, 7; Banerji, 1938, 102; Biswas, 1942, 196/199); in stagnant bay in lake at Kodaikanal ( ! ), tank at Ananthapur, Malabar ( ! ), in a pool near waterfall, Tirupati ( ! ), tank at Sholingur ( ! ) and Yercaud lake ( ! ); Maymyo, Kamuyut and Rangoon in Burma (Skuja, 1949, 49).

### Var. **attenuata** W. and G. S. West

On some new and freshwater Algae, J. roy, micro. Soc., 1896: 165, pl. 4, fig. 58. 1896; Frémy, Myxo. d'Afr. équat. franc., 222, 1929; Geitler, Kryptogamenflora, 972, 1932.

Trichome 2–2.3 μ broad, longer than the type, ends prominently attenuated.

Forming a bluish green stratum on *Riccia fluitans* in a drain leading to the lake, Khajiar, Punjab State, India (Gupta, 1950, 111).

Biswas (1934, p. 11, pl. 1, fig. 3) has recorded an *Oscillatoria splendida* growing among other algae in a ditch at Shillong. The trichome of this Assamese alga is 2 μ broad and the cells 3–5 μ long. The apices of this algae were very characteristic according to him, and were more like those of var. *attenuata*. Gupta does not give any description or figures of this variety.

### 59. **Oscillatoria prolifica** (Grev.) Gomont

Monogr. Oscillariées, 205, pl. 6, fig. 8, 1892; Forti, in De Toni, Sylloge Algarum, 5: 149, 1907; Geitler, Kryptogamenflora, 973, fig. 620c, 1932.

Trichome straight or curved, not constricted at the cross-walls, at the ends gradually attenuated, 2.2–5 μ broad, seldom single, mostly forming purple red, in irregular groups or bundles; cells nearly quadrate or longer, seldom shorter than broad, 4–6 μ long, septa often granulated, gas-vacuoles present, end cells capitate, with calyptra.

In a roadside pond, Namdur, Andhra Pradesh (Rao, C. B., 1938a, 92).

### 60. **Oscillatoria rubescens** DC ex Gomont

D. C., Notice sur la Matière qui colora en rouge la lac de Morat au printemps de 1825, Mém. Soc. Phys. Sc. Hist. Nat. Genève, 3(2): 29, fig., 1825; Gomont, Monogr. Oscillariées, 204, pl. 6, figs. 6, 7, 1892; Forti in De Toni, Sylloge Algarum, 5: 148, 1907; Geitler, Kryptogamenflora, 972, fig. 620a, b, 1932.

Pl. 42, Fig. 12

Trichome straight, at the ends gradually attenuated, 6–8 μ broad, not constricted at the cross-walls, sometimes forming a purple red, or violet, free-swimming bundles; cells $\frac{1}{2}$–$\frac{1}{3}$ as long as broad, 2–4 μ long, often granulated at the septa, with gas-vacuoles; end cell capitate, with convex calyptra.

Planktonic in a tank, Senadiniya-gewawewa near Haberane in Ceylon (Crow, 1923b, 141).

Rao, C. B. (1937b, 367) described a narrower form (trichomes 4.8–6.4 μ broad, and cells 1.2–4 μ long) growing on wet soils, Chunar near Benaras and on stones at the edge of a pond, Polamur in Andhra Pradesh (1938a, 92).

In a tank at Ananthapur, Shimoga Dist., Mysore State ( ! ).

The Ananthapur alga is narrower than the type (3.9–5.2 μ broad). In this it resembles *O. prolifica* (Grev.) Gom. The cells are never more than $\frac{1}{2}$ as long as broad. (Pl. 37, Figs. 9, 18).

### 61. **Oscillatoria agardhii** Gomont

Monogr. Oscillariées, 205: 1892; Forti in De Toni, Sylloge Algarum, 5: 149, 1907; Geitler, Kryptogamenflora, 974, figs. 618, 621, 1932; Frémy, Cyano. cotes d'Eur., 123, pl. 31, fig. 1, 1933.

Trichomes straight or somewhat curved, not constricted at the cross-walls, at the ends gradually tapering, 4–6 μ broad, free-swimming, forming a bundle or a leathery thallus; cells mostly shorter than long, quadrate, 2.5–4 μ long, granulated at the septa, with gas-vacuoles; end cells convex, sometimes bluntly conical, or more or less pointed, with a convex calyptra, seldom capitate.

Planktonic in freshwater pools, tanks, and in rivers and on moist soil.—Tank Basawakulam in Ceylon (Crow, 1923b, 141), Benaras (Rao, C. B., 1936, 173), Madras (Ganapathi, 1940b, 76), Calcutta (Biswas, 1942, 199), River Ravi, Punjab (Singh, V. P., 1941, 252); Rangoon in Burma (Skuja, 1949, 46).

Both Singh, V. P. and Skuja record from Punjab and Rangoon forms which are much broader; the Delhi form was 5.7–7.6 μ broad, while the Rangoon form was up to 9.5 μ.

Lemmermann described the formation of a delicate sheath. But this according to Wislough does not appear to be a constant feature. Similar formation of sheaths has also been reported in other *Oscillatoria* spp.

Holsinger (Hydrobiologia, 7: 16, fig. 4A, 1954) describes a form in which the septa are not granulated — trichome free-floating, solitary, straight throughout, seldom exceeding 100 μ in length, tapering slightly at one end which is capitate, cells 3.5–4 μ broad, 1–3 μ long, not constricted at the septa, with large pseudovacuoles.

### 62. **Oscillatoria raciborskii** Wolosz.

Bull. Acad. Sc. Cracovie, 6: ser. B., 686; pl. 33, fig. 4a, b, 1912; Geitler, Kryptogamenflora, 974, fig. 618, g, h, 1932.

Pl. 37, Fig. 15

Trichome single, yellow-green, very long, not constricted at the cross-walls, 8–9 μ broad, attenuated at the ends, curved; cells ½ times as long as broad, at the ends filaments nearly quadrate, with gas-vacuoles; end cell pointed conical, without calyptra.

Slow sand filters, Madras (Ganapathi, 1940a, 246); in a rainwater pool, Pudukkotah ( ! ).

### 63. **Oscillatoria deflexa** W. et G. S. West

Antarctic Exped., 7, 1911; Geitler, Kryptogamenflora, 974, fig. 622, b, c, 1932.

Trichome single, or arranged in spirally coiled bundles, at the apices gradually attenuated, and slightly curved, not constricted at the cross-walls, blue-green, cells 0.9–1 μ broad, 2.4–2.9 μ long; end cell tapering, without calyptra.

Type not recorded.

#### Var. **crassa** Woronichin

Mat. Alg. Veg. Kulundinsteppe, 38, 1929; Geitler, Kryptogamenflora, 975, 1932.

Trichome 1.8 μ broad.

On moist ground on the banks of River Ravi, Punjab (Singh, V. P., 1941, 252).

### 64. **Oscillatoria calcuttensis** Biswas

Road slimes of Calcutta, J. Dept. Sci., Calcutta Univ., 7 : 5, 1925; Geitler, Kryptogamenflora, 976, 1932.

Pl. 42, Figs. 20, 21

Thallus leathery brown; trichomes parallel straight, not constricted at the cross-walls, 2 μ broad, at the ends briefly attenuated, curved or bent; cells 2–5 times as long as broad, 6–10 μ long, cross-walls with 3 granules, blue-green, end cell conical, pointed, not capitate.

Road slimes, Calcutta (Biswas, *loc. cit.*).

Rao, C. B. (Myxophyceae Madras Presy., I, J. Indian bot. Soc., 17: 92, 1938a) describes a form:

Trichome single, bent or tortuous, with usually straight ends, 1.9–2.4 μ broad; cells 2.4–8 μ long, septa with one to four granules on either side.

In stagnant waters of rice-fields.—Namdur, Polamur and Palacol, and floating in ponds, Palacol in Andhra State (Rao, C. B., *loc. cit.*).

### 65. **Oscillatoria lemmermannii** Wolosz.

Bull. Acad. Sc. Cracovie, 6: ser. B., 687, pl. 34, fig. 26, 1912; Geitler, Kryptogamenflora, 975, fig. 618i, 1932.

Trichome pale blue-green, single, straight, slightly bent, not constricted at the cross-walls, 2–2.5 μ broad, ends gradually tapering, curved; cells 2–3 times as long as broad, 4–6 μ long, septa granulated, calyptra not known.

On moist soil, Benaras (Rao, C. B., 1937b, 367). (Pl. 40, Fig. 10).

### 66. **Oscillatoria acutissima** Kufferath

Contribution a l'étude Flore algologiques du Luxembourg meridionale, II, Ann. biol. lac., 7: fig. 15, 1914; Geitler, Kryptogamenflora, 976, fig. 622d, 1932.

Trichome free floating or forming gelatinous and leathery, blue-green thallus, trichomes 1.5–2 μ broad, cells 3–7 μ long, little constricted at the cross-walls; trichome at the ends attenuated, and curved.

In a stagnant pond, Kamayut, Burma (Skuja, 1949, 45).

### 67. **Oscillatoria kuetzingiana** Näg.

in Kützing, Species Algarum, 238, 1849; Forti in De Toni, Sylloge Algarum, 5: 170, 1907; Geitler, Kryptogamenflora, 975, 1932.

Trichome 1.8–2 μ broad, at the ends slightly attenuated, slightly curved; cells somewhat longer than broad.

On the barks of *Tectona grandis*, Calcutta (Bruhl and Biswas, 1923, 3).

The description of the type is very meagre. The following description is given by Bruhl and Biswas of their Calcutta alga (Bruhl and Biswas, 1923, p. 3, pl. 1, fig. 5a, b).

Forming a smooth, continuous covering on the barks of *Tectona grandis*, the covering being when dry, papery, shining, about ½ mm thick, greenish black, when moistened with water bluish green, slimy, the filaments parallel to each other, closely adhering to the bark, straight, somewhat attenuated towards the apex, not capitate, constricted at the joints, 1.5–2 μ thick, moving straight onwards or oscillating to and fro with their upper part; cells 2.5–3 μ long, contents bluish green finely granular with one or two thicker granules near the centre and two similar granules near each dissepiments, dissepiments conspicuous.

Hansgirg considers this species a variety of *O. amphibia.*

### 68. **Oscillatoria earlei** Gardner

New Myxophyceae from Puerto Rico, Mem. N. Y. bot. Gdn., 7: 36, pl. 8, fig. 70, 1927; Geitler, Kryptogamenflora, 976, fig. 615a, 1932.

Pl. 38, Fig. 15

Trichome short, straight, curved or bent at the ends, attenuated, 2.2–2.4 μ broad, not constricted at the cross-walls; cells quadrate to 2½ times longer than broad, end cells prominently pointed.

In a beach pool, Madras ( ! ).

The ends of the trichome in the Madras alga are not bent.

### 69. **Oscillatoria subproboscidea** W. et G. S. West

Brit. Antarctic Exped., 1: 7, pl. 293, pl. 25, figs. 91–94, 1911; Geitler, Kryptogamenflora, 979, fig. 618c, 1932.

Trichome in between other algae, free-swimming, olive to blue-green, straight, slightly bent, ends attenuated, bent, hooked; cells 8.2–9 μ broad, 3–4 μ long, not constricted at the cross-walls; end cells short, blunt, and convex with slightly thickened outer wall.

Attached to rocks in a water course, Nettayam, Travancore (Parukutty, 1940, 121).

The Travancore form is only 4.2–6 μ broad.

### 70. **Oscillatoria paucigranata** Bruhl et Biswas

Algae of the Bengal Filterbeds, J. Dept. Sci., Calcutta Univ., 14: 5, pl. 1, fig. 7, 1922a; Geitler, Kryptogamenflora, 980, 1932.

Filaments solitary, among other filamentous algae, elongate, straight or moderately curved, very slightly tapering towards the apex, apical cell rounded or obtuse, neither capitate nor calyptrate, lower cells 3–4 μ broad, 2–3 μ long, usually shorter than broad, sometimes nearly square, cell-contents dark greenish blue, very minutely granular interspersed with a small number of distinctly larger granules, evidently placed close to the margin, not rarely in pairs, either near the dissepiment, or remote from it, but never forming a row on either side of the septa.

Khulna filter beds, Pulta Waterworks, and in the River Hooghly (Bruhl and Biswas, *loc. cit.*; Biswas, 1942, 196).

### 71. **Oscillatoria salina** Biswas

Flora of Salt Lakes, J. Dept. Sci., Calcutta Univ., 8: 21, pl. 6, fig. 6a-d, 1926; Geitler, Kryptogamenflora, 978, fig. 624, 1932.

Plant mass forming a deep blue-green thin membrane extending over the muddy soil and finally after being separated floating on the surface of the water; filaments lying side by side in the stratum, straight, elongate, erect, scarcely curved, fragile, rapidly moving, not at all constricted at the joints, 3–5 μ diam., apices of trichome straight, briefly tapering ending acuminately in a sharp point, hooked or twisted, not capitate; apical cell mucronate hyaline, calyptra absent; cells shorter than broad, 1.5–2 μ long, sometimes filament may be interrupted by inflated refringent cells; transverse septa indistinct, not granulated, cell contents finely uniformly granular, almost homogeneous, blue-green.

In salt lakes, Calcutta (Biswas, *loc. cit.*), on moist soil, Benaras (Rao, C. B., 1937b, 3678), roadside drain, Calcutta (Banarji, 1938, 103), and in the river Hooghly, Calcutta (Biswas, 1942, 196).

### f. **major** f. nov.

Pl. 37, Figs. 16, 17

Trichome single, 6.6–7.9 μ broad, not constricted at the cross-walls, cells always shorter than broad, apex bent or curved, apical cell not hyaline, calyptra absent.

In salt pans, Pakala.

### 72. **Oscillatoria animalis** Ag. ex Gomont

Agardh, Aufzählung, Flora, 10: 632, 1827; Gomont, Monogr. Oscillariées, 227, pl. 7, fig. 13, 1892; Forti in De Toni, Sylloge Algarum, 5: 178, 1907; Frémy, Myxo. d'Afr. équat. franc., 223, fig. 193, 1929; Geitler, Kryptogamenflora, 978, fig. 603a, 1932.

Pl. 40, Fig. 14

Thallus dark blue-green; trichomes straight, not constricted at the cross-walls, briefly attenuated at the ends and slightly bent, 3–4 μ broad, blue-green, cells mostly shorter up to ½ as long as broad, seldom longer, 1.6–5 µ long, not granulated at the cross-walls; end cell pointed conical or acute, no calyptra, not capitate.

In ponds and ditches in Paddy fields, in road slimes, in river plankton, on the barks of trees, on moist soil. — Henaratgodha in Ceylon (West & West, 1902, 204), Maymyo islands in Burma (Ghose, 1927d, 255); Calcutta (Biswas, 1925, 5; Banerji, 1938, 103; Biswas, 1942, 199), Benaras (Rao, C. B., 1937b, 167) and Puri in Orissa (Rao, C. B., 1938b, 167).

f. **tenuior** Stockmeyer

Krypt. exs. Mus. Palat. Vindob., nr., 428; Geitler, Kryptogamenflora, 978, 1932.

Trichomes 1.8–2.5 µ broad; cells 2–4.8 µ long.

On moist soil, Narsapur in Andhra (Rao, C. B., 1938a, 92), in cultures of paddy field soils from Goregaon, and Dahisar in Bombay (Gonzalves and Gangla, 1949, 54).

73. **Oscillatoria acuminata** Gomont

Monogr. Oscillariées, 227, pl. 7, fig. 12, 1892; Forti in De Toni, Sylloge Algarum, 5: 177, 1907; Frémy, Myxo. d'Afr. équat. franc., 222, fig. 192, 1929; Geitler, Kryptogamenflora, 978, fig. 603d, 1932.

Pl. 38, Fig. 7 & Pl. 40, Fig. 13

Thallus blue-green; trichome more or less straight, not constricted or slightly constricted at the cross-walls, 3–5 µ broad, at the ends briefly tapering, sharply pointed, bent; cells longer than broad, rarely subquadrate, 5.5–8 µ long, sometimes granulated at the cross-walls; end cell mucronate, without calyptra.

Mouth of River, Pandure in Ceylon (West & West, 1902, 204).

Dixit (1936, 103) and Rao, C. B. (1937b, 368) have recorded forms one each from Bombay and Benaras which are essentially characterised by short cells (cf. Setchell and Gardner's form, Geitler, 1932, p. 978).

f. **tenuis** Parukutty

Collection of Algae from Assam, Proc. Indian Acad. Sci., B, 9: 234, 1939.

Trichome 1.6–1.8 µ broad, cells 3.3–4.8 µ long.

On soil near a hot spring, Garampani, Assam (Parukutty, *loc. cit.*).

74. **Oscillatoria acuta** Bruhl et Biswas, orth. mut. Geitler

Bruhl & Biswas, Indian Bark algae, J. Dept. Sci., Calcutta Univ., 5: 3, pl. 1, fig. 6a and b, 1922; Geitler, Kryptogamenflora, 978, 1932.

Pl. 39, Figs. 5, 8

Trichomes either solitary or a number of them parallel to each other aggregated into bundles of moderate size, hardy, brittle, not constricted at the cross-walls, 4–6 μ thick, 70–400 μ long, usually quite straight, narrow or accuminate towards the subobtuse, non-capitate, non-calyptrate apex, which may be straight but is more often rather abruptly bent aside; cells 3–4 μ long, contents bluish green, finely granular, sometimes with some larger granules close to the surface.

On the barks of trees, Calcutta (Bruhl and Biswas, *loc. cit.*), road slimes, Calcutta (Biswas, 1925, 6), and attached to grass-blades in lowland rainwater pools (Biswas, 1936, 121).

Geitler (1932) made an orthographic change from *O. acula* to *O. acuta.*

### 75. **Oscillatoria cruenta** Grun.

in Rabenhorst, Fl. Eur. Alg., 2: 100, 1865; Forti in De Toni, Sylloge Algarum, 5: 182, 1907.

Thallus mucuous, dark purple, trichome pale brown, 4–7 μ broad, cells 2–4 μ in length, equal to or 1/6 as long as broad, transverse walls granulated, apex obtuse, straight, rarely slightly bent.

Floating in the tank Malawewa near Kokirawa in Ceylon (Crow, 1923b, 141).

### 76. **Oscillatoria brevis** (Kütz.) Gomont

Monogr. Oscillariées, 229, pl. 7, figs. 14, 15, 1892; Forti in De Toni, Sylloge Algarum, 5: 180, 1907; Frémy, Myxo. d'Afr. équat. franc., 223, fig. 195, 1929; Geitler, Kryptogamenflora, 977, fig. 619a, 1932; Frémy, Cyano, des cotes Eur., 125, pl. 31, figs. 9–10, 1933.

Thallus expanded, olivaceous; trichome blue-green, straight, not constricted at the cross-walls, ends briefly attenuated, more or less bent, not capitate, 4–6.5 μ broad, blue-green; cells 1/2–1/3 times as long as broad, 1.5–3 μ long, not granulated at the septa; end-cell rounded, conical, calyptra absent.

In tanks, puddles, pools, in salt lakes, in creeks and in soil cultures.—Khaeng, Pegu, Kadeng-choung near Natmadhi (Martens, 1871b, 462 Zeller, 1873b, 177; Theobald, 1883, 24); Sinchal, Sikkim Himalayas (Martens, 1870a, 10), Salt lakes, Calcutta (Martens, 1871a, 173), in a pond at Dhapa near salt lake (Banerji, 1938, 102), Madhubani in Bihar (Rao, C. S., 1939, 149), New Delhi (Rao, C. S., 1940, 129); in soil culture, Lahore (Singh, H. D., 1933, 106).

## SPECIES INQUIRENDAE

### **Oscillatoria versicolor** Martens

Proc. Asiatic Soc., Bengal, 40: 173, 1871.

Thallus thin brown to violet; trichome 13 μ broad violet to brownish, sometimes greenish; cells 1/3–1/4 as long as broad, dissepiments with two series of granules; apex straight.

On wet mud, Salt lakes, Calcutta.

### **Oscillatoria viridula** Zeller

Algae collected by Mr. S. Murz in Arracan and British Burma etc., J. Asiatic soc. Bengal, 42(2): 177, 1873a; Hedwigia, 12: 169, 1873; Forti in De Toni, Sylloge Algarum, 5: 181, 1907.

Thallus membranaceous, greenish blue, longe radiante straight, 4.5–5 μ broad, apex attenuated and slightly curved, finely granulated; cells 1/2 as long as broad.

On moist mud, Rangoon in Burma (Zeller, *loc. cit.*).

### **Oscillatoria serpentina** Richter, P.

in Küntze, Rev. gen. Pl., 3: 387, 1898; Forti in De Toni, Sylloge Algarum, 5: 188, 1907.

Stratum dull green trichome when dry pale blue, flexuous, apex slightly attenuated, more or less spiral, not fragile, 5–6 μ broad, apex acute; cells 5–6 μ broad, 1/2–1/3 as long as broad; contents finely granular, septa granulated.

In Fluvis, Western Ghats, Poona.

### **Oscillatoria juliana** Menegh

in Kützing Tab. Phycologicae, 1: 29, pl. 40, fig. 3, 1849; Species Algarum, 242, 1819; Forti in De Toni, Sylloge Algarum, 5: 184, 1907.

Thallus dusky blue or blue-green; trichome 7.5 μ broad, cells shorter than broad, sparsely granulated; cell wall hyaline, constricted, apical cell.

In drains, Sealdah, Calcutta (Martens, 1870a, 10; Prain, 1905, 330).

### **Oscillatoria antillarum** Kütz.

Tab. Phycologicae, 1: 31, pl. 43, fig. 2, 1849; Forti in De Toni, Sylloge Algarum, 5: 158, 1907.

(= *Oscillatoria antillarum* Kütz.).

Thallus black, trichome violet-chalybea, 15–18 μ broad, cells 1/2–1/3 as long as broad, walls densely granulated, contents.

In brackish swamp, Akyab, Burma (Zeller, 1873a; Theobald, 1883, 24).

### **Oscillatoria granulosa** Martens

In dense dark green patches on stones in Pywoon-choung, Tonkyghat, Karen country, Burma (Martens, 1871b).

### **Oscillatoria interrupta** Corda (?)

Alm. de Carlsb., 6: 216, pl. 6, fig. 78, 1835.—Above Senadah, Sikkim Himalayas; on muddy ground of dried up banks, Botanical Gardens, Calcutta (Martens, 1870a, 10; 1871a, 170; Prain, 1905, 330, as *O. interrupta* Martens (!) ).

### **Oscillatoria kurziana** Martens

A third list of Bengal Algae, Proc. Asiatic Soc. Bengal, 39: 12, 1870.—Shallow water in flower pots, Botanical Gardens, Calcutta.

### **Oscillatoria tenerrima** Lyngbye *non* A. Br.

On wet mud, Salt lakes, Calcutta (Martens, 1871a, 173; Prain, 1905, 333).

## **TRICHODESMIUM** Ehrenb.

Ehrenberg, Neue Beobachtungen über blutartige Erscheinungen in Aegytien, Arabien und Siberien, in Poggendorff's Ann. Phys. Chem., 18: 506, 1830: Gomont, Monogr. Oscillariées, 193, 1892, *non* Chevall, 1826.

= *Skujaella* J. De Toni, Diagnoses Algarum novarum, 1 (4): 397, 1938.

Trichome cylindrical without sheath, forming free-swimming bundles or flocculent masses, through diffluent mucilage, apex more or less straight, slightly capitate; typically pelagic, forming waterbloom in high seas.

Type species: *Trichodesmium erythraeum* Ehrenb. (= *Skujaella erythraea* (Ehrenb.) De Toni, J.

Many accounts have been published in the last century on the colouration of the high seas caused by species of *Trichodesmium* forming extensive blooms (*see* Hassall, Brit. Freshwater Algae, 1845; Collingwood, Trans. roy. micro. Soc., 16: 85–92, 1868; Hauck, Hedwigia, 27: 93, 1888; Schütt, Das Pflanzenleben der Hochsee, 39, 1893).

### KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Trichomes distinctly attenuated | 2 |
| 1. | Trichomes not attenuated | 1. *T. thiebautii* (p. 243) |
| 2. | Trichomes unconstricted at the cross-walls | 2. *T. hildebrantii* (p. 245) |
| 2. | Trichomes constricted | 3 |
| 3. | Marine, trichomes 7–11 (–21) μ broad | 3. *T. erythraeum* (p. 245) |
| 3. | Freshwater, trichomes 5–6 μ broad | 4. *T. lacustre* (p. 246) |

### 1. **Trichodesmium thiebautii** Gomont

Gomont, J. de Bot., 4: 356, 1890; Monogr. Oscillariées, 197, pl. 6, figs. 2–4, 1892; Forti in De Toni, Sylloge Algarum, 5: 203, 1907.

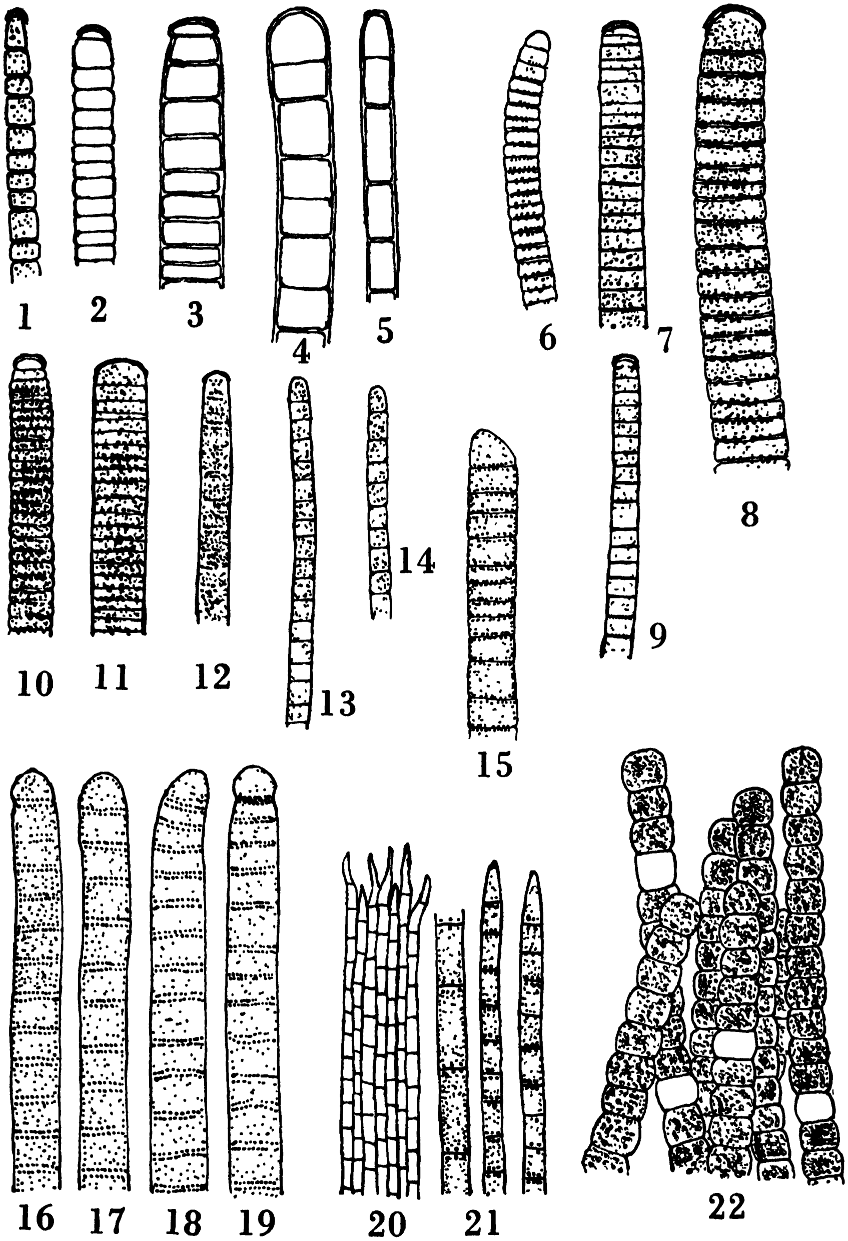

PLATE 42, Figs. 1–22.

1, 2. *Trichodesmium erythraeum* Ehnbg. (after Gomont); 3. *T. hildebrantii* Gom. (after Gomont); 4, 5. *T. thiebautii* Gom. (after Gomont); 6. *Oscillatoria nigroviridis* Thwaites (after Gomont); 7, 9. *O. irrigua* Kütz. (after Gomont); 8. *O. margaritifera* Kütz. (after Gomont); 10. *O. sancta* (Kütz.) Gom. (after Gomont); 11. *O. limosa* Ag. (after Gomont); 12. *O. rubescens* DC (after Gomont); 13, 14. *O. tenuis* f. *tergestina* Rabenh. (after Smith); 15. *O. tenuis* Ag. (after Gomont); 16–19. *O. raoi* De Toni (after Rao, C. B.); 20, 21. *O. calcuttensis* Biswas (after Biswas); 22. *Trichodesmium lacustre* Klebh. (after Smith).

= *Oscillatoria thiebautii* (Gom.) Geitler, Kryptogamenflora, 967, figs. 617c, d, 1932.

= *Skujaella thiebautii* (Gomont) De Toni, J., Noter. nomencl. algol., IX, 292, 1939.

Pl. 42, Figs. 4, 5

Trichome in free swimming bundles, partly growing winding like a rope, blue-green, not constricted at the cross-walls, at the apices briefly attenuated or thickened, 7–16 μ broad; cells up to 2 times as long as broad, sometimes nearly quadratic, 8–26 μ long.

Planktonic all round the coast of peninsular India, Ceylon etc., and neighbouring islands (Zanardini, 1872, 158; Murray, 1887, 44; Cleve, 1901, 13; Karsten, 1907, 402; Iyer, 1927, 1–4; Iyer, Menon and Menon, 1936, 97; John and Menon, 1942; Iyengar and Desikachary, 1944, 58; Chidambaram and Mukundan Unny, 1944, 267; Chacko, 1942, 404; 1950, 167).

This alga has been reported as occurring extensively in blooms in the West coast of India near Malabar and also near Krusadai etc., and have been found to cause fish mortality.

### 2. **Trichodesmium hildebrantii** Gomont

Monogr. Oscillariées, 197, pl. 6, fig. 7, 1892:

= *Trichodesmium ehrenbergii* forma *indica* Hauck, Ueber einige von J. M. Hildebradt in Rothem Meere und Indischen Ocean gesammelte Algen, Hedwigia, 17: 93, 1888.

= *Trichodesmium indicum* Lemmermann, Ergebn. Pacif., 395, 1899.

= *Oscillatoria hildebrantii* (Gomont) Geitler, Kryptogamenflora, 968, 1932.

= *Skujaella hildebrantii* (Gomont) De Toni, J., Noter. nomencl. algol., IX, 292, 1939.

Pl. 42, Fig. 3

Trichome in free swimming bundles, 13–22 μ broad, unconstricted at the cross-walls, slightly attenuated at the apex; cells up to ⅓ as long as broad.

Indian Ocean near Ceylon (Thwaites in Herb. Montagne; Ferguson in Ceylon Alg., Mac. Vicat in Herb. Thuret, all ex Gomont, 1892b, 197).

### 3. **Trichodesmium erythraeum** Ehrenberg ex Gomont

Ehrenberg, in Poggendorff's Ann. Phys. Chem., 18: 506, 1830; Gomont, Monogr. Oscillariées, 196, pl. 5, figs. 27–30, 1892.

= *Trichodesmium ehrenbergii* Mont., Mem. sur le phenom, de la color de la mer Rouge, Ann. Sci. nat., ser. 3, Bot. 2: 360, pl. 10, fig. d, 1844.

= *Oscillatoria erythraea* (Ehrenb.) Geitler, Kryptogamenflora, 968, figs. 617a, d, 1932.

=*Skujaella erythraea* (Ehrenb.) De Toni, J. Diagnoses Algarum novarum, I, Cent. 5: 477, 1938.

Pl. 42, Figs. 1, 2

Trichomes in free swimming purple red bundles, straight, parallel, constricted at the cross-walls, the ends gradually attenuated, 7–11 μ broad rarely up to 21 μ; cells as long as broad or up to ⅓ as long as broad, 5.4–11 μ long; apex with a depressed conical or convex calyptra.

Planktonic in Indian Ocean and along the peninsular coast (Zanardini, 1872, 158; Cleve, 1901, 12; Karsten, 1907, 402; Murray, 1887, 44; Iyengar, 1927, 1; Iyer, Menon, and Menon, 1936, 97; Iyengar and Desikachary, 1944, 58; Chidambaram and Mukundan Unny, 1944, 267; Chacko, 1942, 404; 1950, 167; John and Menon, 1952).

### 4. **Trichodesmium lacustre** Klebahn

Forschungsber. Biol. Stat. Plön, 3: 13, 1895.

= *Oscillatoria lacustris* (Klebh.) Geitler in Pascher's Süsswasserflora, 12: 362, 1925; Kryptogamenflora, 955, fig. 9a, 1932.

Pl. 42, Fig. 22

Trichomes straight, arranged parallel forming free floating bundles, or masses, not attenuated or slightly attenuated, end cells rounded, not capitate; cells shorter than broad, short barrel-shaped, 5–7 μ broad, and 3–7 μ long.

Free floating in cantonment gardens, Rangoon in Burma (Skuja, 1949, 49); in a laboratory tub, Madras ( ! ).

## CRINALIUM Crow

*Crinalium*, a new genus of Cyanophyceae, Ann. Bot. Lond., 41: 165, 1927.

Filaments bent like a hair pin, mostly loosely spirally bent, at the ends slightly attenuated, with a thin sheath; cross-walls delicate, seen only after differential staining, hormogones present.

Type species: *Crinalium endophyticum* Crow.

A single species known from the region.

### **Crinalium magnum** Fritsch et John

An ecological and taxonomic study of the algae of the British soils, II, Ann. Bot. Lond., 6: 393, fig. 8A, 1942.

Pl. 46, Figs. 7, 8

Trichomes straight, flattened, never spirally twisted or bent upto 0.5 mm in length, mostly shorter; sheath narrow, diffluent, closed at both ends and visible only after staining; trichomes slightly constricted at the cross-walls which are non-granulated; ends not attenuated, end cells slightly larger than the others with a convex and slightly thickened outer margin; cells up to 18 μ broad and 1.5–3 μ long.

Uncultivated red soil, Vandalur near Madras (Mitra, 1951, 362).

## KATAGNYMENE Lemm.

Ergebn. Reise Pazifik., Abh. nat. Ver. Bremen, 16: 354, 1899.

Trichome single, free-swimming with a thin or broad gelatinous sheath.

Type species: *K. pelagica Lemm.*

### KEY TO THE SPECIES

1. Filaments spirally coiled .................................. 1. *K. spiralis* (p. 247)
1. Filaments not spirally coiled ............................ 2. *K. pelagica* (p. 247)

### 1. **Katagnymene spiralis** Lemm.

Ergebn. Reise Pazifik, in Abh. nat. Verein, Bremen, 16: 354, pl. 3, figs. 41, 47–49, 1899; Karstens, Indisches Phytoplankton in Wiss. Ergebn. Deutsch. Tiefsee-Exp., 2: 49, pl. 45, 1907; Forti in De Toni, Sylloge Algarum, 5: 382, 1907; Geitler, Kryptogamenflora, 983, fig. 628, 1932.

Pl. 47, Fig. 7

Trichome irregularly spirally coiled, 20–22 μ broad; cells 3–4 μ long, ends rounded; gelatinous sheath 150–168 μ thick, colourless.

Indian ocean (Lemmermann, 1899, 354, Karsten, 1907, 401).

### 2. **Katagnymene pelagica** Lemm.

Ergebn. Reise Pazifik, Abh. nat. Verein, Bremen, 16: 354, pl. 3, figs. 38–40, 42, 1899; Karsten, Indisches Phytoplankton, Wiss, Ergebn. Deutsch. Tiefsee Exped. 2: 401, pl. 45, 1907; Forti in De Toni, Sylloge Algarum, 5: 381, 1907; Geitler, Kryptogamenflora, 983, 1932.

Pl. 47, Figs. 6, 10

Trichome straight or bent, 16 μ broad; cells 3–4 μ long; end cells rounded or with a calyptra; gelatinous sheath up to 100 μ thick, colourless.

Indian ocean (Karsten, 1901, 401).

## PORPHYROSIPHON Kützing

Tab. Phycologicae, 2: 7, pl. 27, fig. 1, 1850; Gomont, Monogr. Oscillariées, 331, 1892.

Trichomes single, rarely two in a sheath; sheath firm, lamellated, red or reddish brown, when old at the extreme ends open; filaments when young with attenuated and closed ends, more or less contorted and forming an expanded thallus, sparingly branched.

Type species: *P. notarisii* (Menegh.) Kütz.

A single species is reported from all over the region. The genus has many characters of *Lyngbya* and the separation of the genus is merely conventional (see also Bharadwaja, 1940). Frémy (Mus. d'Hist. Nat. Bull. 33: 115, 1927) and Nielson (J. Florida Acad. Sci., 17: 87, 1954) recognise a second species, *P. fuscus* Gomont ex Frémy.

### **Porphyrosiphon notarisii** (Menegh.) Kütz. ex Gomont

Kützing, Tab. Phycologicae, 2: 7, pl. 27, fig. 1, 1849; Gomont, Monogr. Oscillariées, 331, pl. 12, figs. 1, 2, 1892; Forti in De Toni, Sylloge Algarum, 5: 314, 1907; Frémy, Myxo. d'Afr. équat. franc., 122, figs. 108 and 109, 1929; Geitler, Kryptogamenflora, 986, fig. 631, 1932.

Pl. 47, Fig. 9

Filaments variously bent, densely aggregated, forming a tomentose, expanded, dull reddish brown layer; sheath firm, sometimes thin, mostly very thick and lamellated, orange to purple-red, at the ends often colourless, and narrowing to the apex, the inner lamellae alone coloured, the outer lamellae colourless; sheath coloured violet by chlor-zinc-iodide; trichome constricted at the cross-walls or unconstricted, blue-green; cells 8–19 μ broad, as long or up to $\frac{1}{3}$ as long as broad, 4.5–12 μ long; end cell obtuse-attenuated; filaments occasionally branched, or occasionally into two short pieces of trichome.

On barks of trees, Tyoben, Pegu and Rangoon; Choung-menah and Wa Choung in rice fields; on leaves of *Calamus*, Rangoon in Burma (Martens, 1871b, 462; Zeller, 1873a, 172; 1873b, 182; Theobald, 1883, 22; Skuja, 1949, 55); Ceylon (Ferguson ex Gomont, 1892, 331); on soil, tree trunks etc., Simla, Matheran near Bombay, Calcutta, Berkuda island in Orissa, Cherrapunji, Shembaganur etc. (Belangor ex Gomont, 1892, 331; Hein ex Gomont, 1892, 331; Schmidle, 1900b, 161; Bruhl and Biswas, 1923, 13; Biswas, 1924, 363; 1934, 13; Frémy, 1942, 21); on moist soils around Madras ( ! ).

Drouet (Brazilian Myxophyceae I, Amer. J. Bot., 24: 602, 1937) includes under *P. notarisii*, *Lyngbya arboricola* Bruhl and Biswas (1923, p. 7) and *L. dendrobia* Bruhl and Biswas (*loc. cit.*). The former has been again reported by Rao, C. B. (1937b, 372; 1938a, 94) as growing on tree trunks in Benaras and Ellore. An examination of the type material is needed to settle this point.

## **POLYCHLAMYDUM** West et West

Welwitsch's Freshw. Afr. Algae, J. Bot. Lond., 35; 271, 1897.

Trichome single or seldom 2–3 in a thick lamellated sheath, inner lamellae of sheath firm, brown, the outer ones colourless, and swollen, or the inner and outer ones of similar structure; filaments unbranched.

Type species: *P. insigne* West et West.

### KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Trichome 17–22 μ broad ............................ | 1. *P. insigne* (p. 249) |
| 1. | Trichome 6–13 μ broad ............................ | 2. *P. varium* (p. 249) |

### 1. **Polychlamydum insigne** West et West

Welwitsch's Freshw. Afr. Algae, J. Bot. Lond., 35: 271, pl. 365, figs. 1, 2, 1897; Forti, in De Toni, Sylloge Algarum, 5: 368, 1907; Frémy, Myxo. d'Afr. équat. franc., 124, fig. 110, 1929; Geitler, Kryptogamenflora, 990, fig. 634a, 1932.

Pl. 47, Figs. 1, 2

Filament 67–105 μ broad; sheath with 5–7 firm yellowish brown inner lamellae and 2–4 colourless, externally even, outer lamellae diffluent; trichome not constricted at the cross-walls, at the ends obtuse, not capitate, olive-green, 17–22 μ broad, cells 1/9–1/11 as long as broad.

Along with other algae in a pond, and on water plants in a pool at Ennore ( ! ).

### 2. **Polychlamydum varium** Ghose

On a collection of Myxophyceae from Mergui and some neighbouring islands, J. Burma Res. Soc., 17: 249, pl. 12, fig. 12, 1927c; Geitler, Kryptogamenflora, 990, 1932.

Pl. 46, Fig. 10

Filaments 25–100 μ broad; sheath lamellated, the inner lamellae dull brown, the outer ones colourless, the middle ones dark brown; trichome 6–13 μ broad, not constricted at the cross-walls; cells shorter than broad; end cells rounded.

On the barks of trees, Kamaw, Kisseraing islands, and in Madaw islands in Burma (Ghose, *loc. cit.*).

According to Geitler (1942, p. 199) this species is not a *Polychlamydum*. He considers that this species is incompletely described.

## DASYGLOEA Thwaites

Engl. Bot., pl. 2941, 1848; Gomont, Monogr. Oscillariées, 346, 1892.

Filaments coiled, branched, forming a mucilaginous thallus; trichomes a few in a broad, colourless or bluish green sheath, arranged away from one another; apex of trichome straight, not capitate.

Type species: *D. amorpha* Thwaites.

Geitler (1932) considers this closely related to *Microcoleus* and *Hydrocoleum*, and forms probably an extreme form of these genera.

Only a single species known from the region.

### **Dasygloea amorpha** Thwaites ex Gomont

Thwaites, Engl. Bot., pl. 2941, 1848; Kützing, Species Algarum, 272, 1848; Gomont, Monogr. Oscillariées, 347, pl. 13, figs. 11–12, 1892; Forti, in De Toni, Sylloge Algarum, 5: 368, 1907; Geitler, Kryptogamenflora, 991, figs. 634, b, c, 1932.

Pl. 47, Fig. 3

Thallus gelatinous; filaments much bent, tortuous, laciniated at the ends, sheath colourless or with inner lamellae yellowish brown, gelatinous or slimy, outside uneven, many times indistinctly lamellated, not coloured violet by chlor-zinc-iodide; trichome constricted at the cross-walls, 4–6 μ broad, 4–13 μ long, end cell stumpy-conical.

In an artificial tank, Peredeniya, Ceylon (West and West, 1902, p. 203).

According to Geitler this species appears to be a developmental stage of some other genera like *Microcoleus*.

## PHORMIDIUM Kütz.

Kützing, Phyc. gene. 190, 1843; Monogr. Oscillariées, 156, 1892.

Filaments many forming a gelatinous or leathery stratum, thallus attached by the lower side, or floating in water with torn margins; sheath present, more or less firm, sometimes agglutinated, sometimes partly diffluent, thin, colourless; trichomes cylindrical, in some constricted at the joints, apices often attenuated, straight or bent, never regularly spirally coiled, capitate or non-capitate, apical cells in many species with a calyptra.

Lectotype: *P. lucidum* Kütz.

Kützing included 28 species under this genus and did not designate the type. Geitler (1942, p. 212) has proposed *P. lucidum* as the type.

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Trichomes constricted at the cross-walls; ends not bent or capitate | 2 |
| 1. | Trichomes not constricted at the cross-walls; ends often bent and capitate | 14 |
| 2. | Trichomes below 3.5 μ broad | 3 |
| 2. | Trichomes broader | 9 |
| 3. | Trichomes up to 2 μ broader | 4 |
| 3. | Trichomes broader | 8 |
| 4. | Trichome 0.6-0.8 μ broad, cells longer than broad | 1. *P. angustissimum* (p. 253) |
| 4. | Trichome 1.5–2 μ broad | 5 |
| 5. | End cell not attenuated | 6 |
| 5. | End cells more or less conical | 2. *P. fragile* (p. 253) |
| 6. | In the mucilage of planktonic organisms | 3. *P. mucicola* (p. 254) |
| 6. | Not so | 7 |
| 7. | Cells longer than broad | 4. *P. africanum* (p. 254) |
| 7. | Cells shorter than broad | 5. *P. foveolarum* (p. 254) |
| 8. | Cells mostly longer than broad | 6. *P. molle* (p. 255) |
| 8. | Cells mostly shorter than broad | 7. *P. jenkelianum* (p. 255) |
| 9. | Trichome not more than 6 μ broad | 10 |
| 9. | Trichome broader | 12 |
| 10. | End cell with a calyptra | 8. *P. dimorphum* (p. 256) |
| 10. | End cell without a calyptra | 11 |
| 11. | Trichome 4–6 μ broad; cells shorter than broad or quadrate | 9. *P. jadinianum* (p. 256) |
| 11. | Trichome 3–4 μ broad; cells shorter than broad | 10. *P. usterii* (p. 257) |
| 11. | Trichome 3–4.5 μ broad; cells ¾-twice as long as broad | 11. *P. abronema* (p. 257) |
| 12. | End cells with a calyptra | 12. *P. microtomum* (p. 257) |
| 12. | End cells without a calyptra | 13 |
| 13. | Trichomes 6–9 μ broad | 13. *P. truncicola* (p. 258) |
| 13. | Trichomes 8–11 μ broad | 14. *P. rotheanum* (p. 258) |
| 14. | Trichomes up to 3 μ broad | 15 |
| 14. | Trichomes broader | 26 |
| 15. | End cell so conical more or less pointed | 16 |
| 15. | End cells not so | 18 |
| 16. | Trichome ends straight | 17 |
| 16. | Trichome ends bent | 15. *P. laminosum* (p. 259) |
| 17. | Trichomes 1–2 μ broad, cells up to 3 times as long as broad | 16. *P. tenue* (p. 259) |
| 17. | Trichomes 2.2–2.4 μ broad, cells quadratic or longer | 17 *P. rubroterricola* (p. 261) |
| 18. | Trichomes up to 1 μ broad | 19 |
| 18. | Trichomes broader | 20 |
| 19. | Cross-walls not granulated | 1. *P. angustissimum* (p. 253) |
| 19. | Cross-walls granulated | 18. *P. bigranulatum* (p. 261) |
| 20. | Cells shorter than broad or quadratic | 21 |
| 20. | Cells longer than broad | 22 |
| 21. | Trichome more or less parallel (1.7–2 μ broad) | 19. *P. bohneri* (p. 261) |
| 21. | Trichome flexuous or nearly parallel 2 μ broad | 20. *P. cebennense* (p. 262) |
| 22. | Trichomes 1.5–2.5 μ broad, thallus purple to violet | 21. *P. purpurascens* (p. 262) |
| 22. | Trichome not so coloured | 23 |

23. Trichomes narrower than 2 μ .......... 24
23. Trichomes broader than 2 μ .......... 25
  24. Trichomes 1.7–2 μ slightly constricted, cells quadratic or longer
  22. *P. luridum* (p. 263)
  24. Trichomes 1.6–1.8 μ unconstricted, cells 3½–4½ times as long as broad
  23. *P. orientale* (p. 263)
25. Trichomes 2–2.5 μ broad, cross-walls granulated .......... 24. *P. valderianum* (p. 263)
25. Trichomes 2.5–3 μ broad, cross-walls not granulated ... 25. *P. mucosum* (p. 265)
  26. Trichomes not attenuated at the apices .......... 27
  26. Trichomes attenuated at the apices .......... 33
27. End cells more or less rounded .......... 28
27. End cells otherwise .......... 31
  28. End cells with a calyptra .......... 26. *P. stagnina* (p. 265)
  28. End cells without a calyptra .......... 29
29. Trichomes up to 6 μ broad .......... 30
29. Trichomes up to 8–10.5 μ broad .......... 27. *P. anomala* (p. 266)
  30. Sheath thick, lamellated, septa granulated, with gas-vacuoles
  28. *P. ambiguum* (p. 266)
  30. Sheath thin, unlamellated, septa not granulated, no gas-vacuoles
  29. *P. subincrustatum* (p. 267)
31. Trichome end cells short conical .......... 30. *P. pachydermaticum* (p. 267)
31. Trichome otherwise .......... 32
  32. Trichomes 5.8–6.4 μ broad, forming a thick calcified thallus
  31. *P. calcicola* (p. 267)
  32. Trichomes 4.5–12 μ broad, not forming a thick calcified thallus
  32. *P. retzii* (p. 268)
33. Trichomes more or less spirally coiled .......... 33. *P. hieronymusii* (p. 269)
33. Trichomes not spirally coiled .......... 34
  34. End cell capitate .......... 41
  34. End cell not capitate .......... 35
35. Thallus with calcium incrustation .......... 34. *P. incrustatum* (p. 269)
35. Thallus without calcium incrustation .......... 36
  36. Filaments up to 5.5 μ broad .......... 37
  36. Filaments broader .......... 39
37. Cells mostly longer up to twice as long as broad .......... 35. *P. corium* (p. 269)
37. Cells mostly quadrate, shorter or longer than broad .......... 38
  38. Cells quadrate or longer than broad, 4–8 μ long, cross walls granulated
  36. *P. inundatum* (p. 271)
  38. Cells mostly shorter than broad, 2–4 μ long ... 37. *P. papyraceum* (p. 271)
39. Trichomes below 7 μ broad .......... 35. *P. corium* var. *capitatum* (p. 271)
39. Trichomes broader .......... 40
  40. Trichomes up to 10 μ broad .......... 38. *P. ceylanicum* (p. 272)
  40. Trichomes 10–12 μ broad, cells very short ..... 39. *P. hansgirgi* (p. 272)
41. End cells conical pointed .......... 42
41. End cells otherwise .......... 43
  42. In freshwater, cells shorter than broad .......... 40. *P. subfuscum* (p. 273)
  42. In marine, cells longer than broad .......... 41. *P. submembranaceum* (p. 273)
43. Trichomes apices straight .......... 44
43. Trichomes apices bent .......... 46
  44. Cells longer than broad .......... 41. *P. submembranaceum* (p. 273)
  44. Cells shorter than broad .......... 45

45. Cells 1–½ as long as broad.................................. 42. *P. favosum* (p. 275)
45. Cells ½–¼ as long as broad .............................. 43. *P. lucidum* (p. 275)
    46. Cells 5.5–9 µ broad, generally ½–⅓ as long as broad 44. *P. uncinatum* (p. 276)
    46. Cells 4–7 µ broad, 1–½ as long as broad ......... 45. *P. autumnale* (p. 276)

### 1. **Phormidium angustissimum** W. et G. S. West.

Welwitsch's African freshwater Algae, J. Bot., Lond., 35: 298, 1897; Forti, in De Toni, Sylloge Algarum, 5: 1907; Frémy, Myxo. d'Afr. équat. franc., 142, 1929; Geitler, Kryptogamenflora, 996, 1932.

Thallus leathery, thin, pale blue-green; trichomes bent, entangled, constricted at the cross-walls, ends not attenuated, straight, 0.6–0.8 µ broad, pale blue-green; sheath colourless, agglutinated; cells cylindrical, 2–8 mostly 4–5 times as long as broad, septa not granulated, apical cell not capitate.

On soil and epiphytic in stagnant waters, Rangoon and Mandalay (Skuja, 1949, 50).

Geitler (1932, 996) doubts whether this is not the same as *P. treleasi.*

Mitra, A. K. (1951, pp. 359, 360, 362) reports a form from cultures of rice-field soil, Siwait near Allahabad, from garden soils and usar soils, Allahabad and from red soil from Vandalur and Red Hills near Madras.

### 2. **Phormidium fragile** (Meneghini) Gomont

Monogr. Oscillariées, 163, pl. 4, figs. 13–15, 1892; Forti, in De Toni, Sylloge Algarum, 5: 220, 1907; Frémy, Myxo. d'Afr. équat. franc., 140, fig. 123, 1929; Geitler, Kryptogamenflora, 999, fig. 636b, 1932; Frémy, Cyano. cotes d'Eur., 86, pl. 22, fig. 6, 1933.

Pl. 44, Figs. 1–3

Thallus mucilaginous, lamellated, yellowish or brownish blue-green; sheath diffluent, not coloured violet by chlor-zinc-iodide; trichomes more or less flexuous, entangled or nearly parallel, distinctly constricted at the cross-walls, septa not granulated, attenuated at the ends, 1.2–2.3 µ broad, pale blue-green; cells nearly quadrate, 1.2–3 µ long; end cell acute-conical, calyptra absent.

On moist soil, also floating in shallow fresh and aestuarine waters.—Berkuda island and Chilka lake (Biswas, 1924, 362; 1932, 187), Bombay (Schmidle, 1900b, 162), Calcutta (Banerji, 1938, 103), Delhi (Rao, C. S., 1940, 130), Poojapura near Trivandrum (Parukutty, 1940, 122); on the walls of a pond in Madras ( ! ).

Mitra (1951, 359/361) reports a form from the rice field soils and uncultivated soils from near Allahabad.

### 3. **Phormidium mucicola** Hub.-Pestalozzi et Naumann

Ber. dtsch. bot. Ges., 47: 86, figs. 1–6, 1929; Geitler, Kryptogamenflora, 997, fig. 637, 1932.

Pl. 15, Fig. 13

Filaments short, straight, 10–20 μ, occasionally up to 50 μ long; sheath very thin, not coloured blue by chlor-zinc-iodide; trichome not attenuated at the ends, more or less distinctly constricted at the cross-walls; cells 1.5–2 μ seldom 1.3 μ broad and more or less twice as long as broad; end cells rounded, seldom slightly conical, calyptra absent; contents granulated, pale bluish.

In ponds and tanks along with *Microcystis flos-aquae*, Cuttack (Rao, C. B., 1938b, 168); with *M. aeruginosa, M. viridis, M. pseudofilamentosa* and *Aphanothece stagnina* in ponds, at Madras ( ! ), Ernakulam ( ! ) and Dacca ( ! ).

The trichomes in the South Indian material are 1–2.6 μ broad.

Skuja (1949, 51) reports a form of this species in the mucilage of *Aphanothece clathrata* etc. in Rangoon, Burma. The trichomes in the Rangoon form are up to 80 μ long.

### 4. **Phormidium africanum** Lemm.

Deutsche Zentr. Afr. Exped., 2: 89, 1911; Frémy, Myxo. d'Afr. équat. franc., 138, 1929; Geitler, Kryptogamenflora, 999, 1932.

Thallus thin, blue-green; filaments straight or variously bent; sheath diffluent, not coloured violet by chlor-zinc-iodide; trichome pale blue-green, distinctly constricted at the cross-walls, not attenuated at the ends, 1.5–2 μ broad; cells quadrate or rectangular, 1.5–4 μ long; end cells truncated, with a small calyptra.

In hot springs at Vajreshwari near Bombay at 40°–54°C (Gonzalves, 1947, 26).

The Bombay alga differs very much from the type (filament 2.7 μ broad; trichome 1.2–1.9 μ broad; cells 5.6–7.5 μ long).

### 5. **Phormidium foveolarum** (Mont.) Gomont

Monogr. Oscillariées, 164, pl. 4, fig. 16, 1892; Forti in De Toni, Sylloge Algarum, 5: 221, 1907; Frémy, Myxo. d'Afr. équat. franc., 139, fig. 121, 1929; Geitler, Kryptogamenflora, 999, fig. 636, c, d, 1932.

Thallus thin, dark-green; trichome flexuous, constricted at the cross-walls, at the ends not attenuated, about 1.5 μ broad, pale blue-green; sheath colourless, diffluent in an amorphous gelatinous mucilage, not coloured violet by chlor-zinc-iodide; cells nearly quadrate or somewhat shorter than broad, 0.8–1.8 μ long, septa not granulated; end cell rounded, calyptra absent.

On moist soils, paddy and wheat field soils and on rocks in a shallow stream.—Lahore (Singh, H. D., 1933, 106), Calcutta (Banerji, 1938, 103), Faridpur (De, P. K., 1939, 125), Delhi (Rao, C. S., 1940, 130), Nettayam in Travancore (Parukutty, 1940, 121), Goregaon, Dahisar, Khandala and Lonavala near Bombay (Gonzalves and Gangla, 1949, 54), partly reclaimed and unreclaimed Usar soils, Allahabad (Mitra, 1951, 359).

The breadth of the trichome in the Indian material varies from 1.2–2 μ.

### 6. **Phormidium molle** (Kütz.) Gomont

Monogr. Oscillariées, 163, pl. 4, fig. 12, 1892; Forti in De Toni, Sylloge Algarum, 5: 219, 1907; Frémy, Myxo. d'Afr. équat. franc., 138, fig. 119, 1929; Geitler, Kryptogamenflora, 1000, 1932; Frémy, Cyano. cotes d'Eur., 85, pl. 22, fig. 5, 1933.

= *Anabaena mollis* Kütz., Species Algarum, 287, 1849.

Pl. 59, Fig. 8

Thallus mucilaginous, thin, light blue-green, sheath more or less diffluent, colourless, not coloured violet by chlor-zinc-iodide; trichome straight, or nearly straight, distinctly constricted at the cross-walls, not attenuated at the ends, 2.7–3.3 μ broad, light blue-green, septa not granulated; cells quadrate, cylindrical or pressed barrel-shaped shorter or longer than broad, 3–7.8 μ long, end cell rounded, calyptra absent.

On mud along the edges of a tank, and in water, Calcutta (Martens, 1871a, 170; also Prain, 1905, 334); in uncultivated and rice-field soils, Allahabad and Red soils near Madras (Mitra, 1951, 359, 360, 362).

### f. **tenuior** W. & G. S. West

The Alg. Fl. Yorkshire, Bot. Trans. York nat. Union, 5: 146, 1902.

Cells 2–2.4 μ broad, 2.2–3.5 μ long.

Rice field soils, Usar and partially reclaimed Usar soils near Allahabad (Mitra, 1951, 359, 362).

### 7. **Phormidium jenkelianum** Schmid, G.

Ber. dtsch. bot. Ges., 32: 126, fig. 2, 1914; Geitler, Kryptogamenflora, 1001, fig. 638, 1932.

Pl. 54, Fig. 7

Thallus brownish black, slimy; trichome brownish blue-green, flexuous, 2–2.6 μ broad, not attenuated at the ends; cells 1/2–1/3 as long as broad, 0.6–1.3 μ long, well constricted at the cross-walls, septa not granulated, sheath delicate, not coloured violet by chlor-zinc-iodide; end cell rounded, truncated, calyptra absent.

In drains and in cultures of paddy-field soils.—Trivandrum (Parukutty, 1940, 122); Thana near Bombay (Gonzalves and Gangla, 1949, 54).

Parukutty describes from Trivandrum a *P. jenkelianum* G. Schmid ( ? ) with filaments 4–6 μ broad and cells 3.3–4 μ long.

### 8. **Phormidium dimorphum** Lemm.

Arch. Hydrobiol. (u. Planktonk.), 4: 187, pl. 5, figs. 25–28, 1908; Geitler, Kryptogamenflora, 1001, fig. 639, 1932.

Pl. 54, Fig. 8

Thallus membranous, broadly expanded, dark blue-green; trichome straight or bent, sometimes arranged parallel, distinctly constricted at the cross-walls, 3.5–5 μ broad, blue-green, at the ends long and prominently attenuated; sheath firm, colourless, thin, not lamellated, close, not coloured violet by chlor-zinc-iodide; cells mostly quadrate, seldom shorter, also longer than broad at the ends, 2–5.5 mostly 3 μ long, not granulated at the cross-walls; end cells long, conical or short rounded and hemispherical but truncated about 2 μ broad and 1.5 μ high calyptra.

On moist soil in a drain, Patna (Rao, C. S., 1939, 150).

In Rao's specimens the trichomes are 5.2–6 μ broad and the cells are 2–4 μ long.

### 9. **Phormidium jadinianum** Gomont

Bull. Soc. Bot. Fr., 40: 161, 1893; Forti in De Toni, Sylloge Algarum, 5: 218, 1907; Frémy, Myxo. d'Afr. équat. franc., 136, fig. 118, 1929; Geitler, Kryptogamenflora, 1002, fig. 640, 1932.

Pl. 55, Fig. 9

Thallus dark-green to olive-green, thin, amorphous; filaments more or ess parallel; sheath thin, diffluent and agglutinated, not coloured violet by chlor-zinc-iodide; trichome olive-green, distinctly constricted at the cross-walls, with straight long acuminate ends, 4–6 μ broad; cells shorter than broad to nearly quadrate, 2–3.5 μ long, contents granulated with a hyaline central area, septa not granulated; end cell acute conical, calyptra absent.

On tree trunks, Lahore (Ghose, 1919, 10).

Ghose records this as *P. ladinianum* Gom., and refers to De Toni, p. 218. The description agrees well with that given by Forti in De Toni. Probably Ghose records *P. jadinianum*.

Rao, C. B. (1936, 173) reports a form of this species growing on soil in Benaras. This form differs from the type in the cells being shorter and in the end cells being bluntly rounded.

### 10. **Phormidium usterii** Schmidle

Ein. neue Algen aus Java und den Philippien, Hedwigia, 6: 414, 1904; Forti in De Toni, Sylloge Algarum, 5: 238, 1907; Geitler, Kryptogamenflora, 1016, 1932.

Thallus thick, mucilaginous, lacerated at the margins; trichomes intricately bent, 3–4 μ broad; sheath thin, or thick and diffluent; cells shorter than broad, often short rectangular, contents homogeneous, blue-green; ends not attenuated, straight; end cells broadly rounded.

In uncultivated soil near Muirabad, Allahabad (Mitra, 1951, 360); on rocks beside a waterfall, at Tirupati ( ! ).

### 11. **Phormidium abronema** Skuja

Zur Süsswasseralgenflora Burmas, 50, pl. 8, fig. 25, 1949.

Thallus coriaceous, lamellated, rarely mucose flocculose, olivaceous, blackish green to light bluish; filaments flexuous, more or less loosely spirally coiled, 4–7 μ broad, sheath moderately thick, hyaline, mucilaginous, commonly diffluent; trichome 3–4.5 μ broad, ends briefly attenuated, distinctly constricted at the cross-walls, cells cylindrical, barrel-shaped, 3/4–2 times as long as broad, septa not granulated, end cell more or less rounded conical.

On moist soil, Rangoon, Kamayut, Kyauktan and Mandalay in Burma (Skuja, *loc. cit.*).

### 12. **Phormidium microtomum** Skuja

Zur Süsswasseralgenflora Burmas, 51, pl. 8, figs. 26 and 27, 1949.

Pl. 43, Figs. 16, 17

Thallus expanded, coriaceous, lamellose, dark greyish-green or light-bluish; filaments more or less straight, 6.5–8 μ broad; sheath thin, colourless, later diffluent; trichome ends briefly or prominently attenuated, 6–7 μ broad, well constricted at the cross-walls, cells 1/3–1/8 as long as broad, 0.8–1.5 μ long, contents blue-green to olivaceous, septa not granulated or indistinct, and finely granulated; apical cell rounded with a hyaline calyptra.

On soil, Burma (Skuja, *loc. cit.*).

### 13. **Phormidium truncicola** Ghose

A systematic and ecological account of a collection of blue-green algae from Lahore and Simla, J. Linn. Soc., Bot. Lond., 56: 338, pl. 3, fig. 3, 1924; Geitler, Kryptogamenflora, 1004, fig. 642, b, 1932.

Pl. 59, Fig. 9

Thallus expanded, membranous, yellow-green or blue-green, sheath diffluent, fibrous; trichomes 6–8 µ broad, nearly parallel, distinctly constricted at the cross-walls; cells nearly as long as broad, attenuated at the apices, calyptra absent.

On trunks of *Acacia modesta* with other blue-greens, Lahore (Ghose, *loc. cit.*).

### 14. **Phormidium rotheanum** Itzigsohn

Rabenhorst, Alg. exsicc. n. 206, 1852; Lemmermann, Kryptogamenflora der Mark Brandenburg, 3: 129, 1910; Geitler, Kryptogamenflora, 1004, 1932.

Thallus thin, dark blue-green; trichome straight or flexuous, slightly constricted at the cross-walls, at the ends attenuated, 8–11 µ broad, blue-green; sheath thin, coloured violet by chlor-zinc-iodide, cells much shorter than broad, 2.7–4 µ long, septa granulated, end cells obtuse conical.

On the barks of trees, Rangoon, Burma (Skuja, 1949, 52).

Gomont (1892, p. 192) includes this species (as *P. rhoteanum* Rabenh.) under "species inquirendae". Geitler (1932) following Lemmermann (*loc. cit.*) recognised this species. In fact the diagnosis of the species is based on Lemmermann's. Forti (1907) includes this under *P. solitare* (Kütz.) Rabenh., which has similarly been placed under "species inquirendae".

#### Var. **capitatum** nom. nov.

= *P. rotheanum* Itzigs. var. Skuja, Zur Süsswasseralgenflora Burmas 52, pl. 8, figs. 31, 32, 1949.

Pl. 45, Figs. 14, 15

Filaments long or short, more or less straight to variously but seemingly regularly spirally coiled, 9–12 µ broad; sheath thin, colourless, sometimes diffluent, outside uneven; trichome 8–10 µ broad, at the ends not or a little attenuated, distinctly constricted at the cross-walls, granulated; cells 1.5–2.7 µ long, contents olive to blue-green in colour; end-cell capitate, somewhat flat to broadly conical or rounded.

Terricolous, Rangoon, Burma (Skuja, *loc. cit.*).

### 15. **Phormidium laminosum** Gomont

Essai class. Nostoc. homo., J. de Bot., 4: 355, 1890; Monogr. Oscillariées, 167, pl. 4, figs. 21, 22, 1892; Forti in De Toni, Sylloge Algarum, 5: 225, 1907; Frémy, Myxo. d'Afr. équat. franc., 146, fig. 130, 1929; Geitler, Kryptogamenflora, 1005, fig. 642c, 1932; Frémy, Cyano. cotes d'Eur., 88, pl. 23, fig. 3, 1933.

Pl. 44, Fig. 6

Plant mass pale blue-green, yellowish or nearly brick red, membranous, expanded, filaments flexuous, densely entangled; sheath thin, mucilaginous, or diffluent, coloured violet by chlor-zinc-iodide; trichome pale blue-green, not constricted at the cross-walls, cross-walls usually inconspicuous, cross-walls with four granules, 1–1.5 μ broad; cells longer than broad, 2–4 μ long; end-cells acute-conical, without calyptra.

On water-logged soil in a rice field, Faridpur, Bengal (Banerji, 1938, 103).

### 16. **Phormidium tenue** (Menegh.) Gomont

Monogr. Oscillariées, 169, pl. 4, figs. 23–25, 1892; Forti in De Toni, Sylloge Algarum, 5: 227, 1907; Frémy, Myxo. d'Afr. équat. franc., 146, fig. 131, 1929; Geitler, Kryptogamenflora, 1004, fig. 642d, e, 1932; Frémy, Cyano. cotes d'Eur., 88, pl. 23, fig. 4, 1933.

= *Leptothrix subtilissima* Kütz., Tab. Phycologicae, 1: pl. 65, 1845.

= *Hyphaeothrix subtilissima* Rabenh., Fl. Eur. Alg., 2: 77, 1865.

Pl. 43, Figs. 13-15 & Pl. 44, Figs. 7-9

Thallus pale blue-green, thin, membranous, expanded; trichome straight or slightly bent, densely entangled, slightly constricted at the cross-walls, attenuated at the ends, 1–2 μ broad, pale blue-green; sheath thin, diffluent, coloured violet by chlor-zinc-iodide; cell up to 3 times longer than broad, 2.5–5 μ long, septa not granulated, cross-walls not commonly visible; end-cell acute-conical, calyptra absent.

On moist surfaces and among other algae in freshwater and salt-water bodies, also in hot springs. — Calcutta (Martens, 1870b, 258; Prain, 1905, 334; Bruhl and Biswas, 1922a, 8; Biswas, 1925, 6; 1926, 23; 1942, 198); Delhi (Rao, C. S., 1940, 130); Henzadah and Rangoon in Burma (Zeller, 1873b, 177; Theobald, 1883, 24; Skuja, 1949, 52); Lahore in Pakistan (Ghose, 1919, 10); hot springs at Setapak, Kuala Lumpur, Malaya (Biswas, 1929, 410); Ceylon (Wille, 1915, 162).

Mitra (1951, 359/360) describes a var. *indica* (*nomen nudum*) from cultures of uncultivated red soil from Vandalur near Madras and soils from wheat and rice fields, Allahabad.

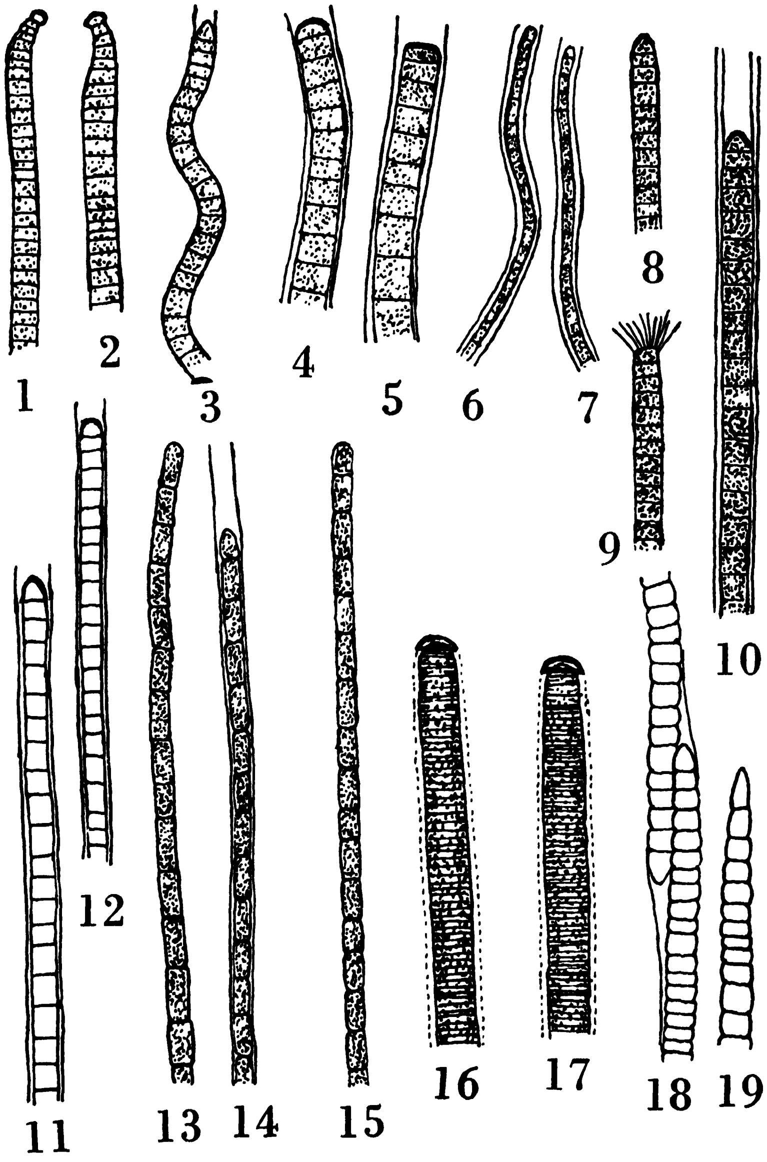

PLATE 43, Figs. 1–19.

1, 2. *Phormidium uncinatum* (Ag.) Gom. (after Gomont); 3. *P. rubroterricola* Gardner (after Gardner); 4, 5. *P. calcicola* Gardner (after Gardner); 6, 7. *P. mucosum* Gardner (after Gardner); 8–10. *P. pachydermaticum* Frémy (after Frémy); 11, 12. *P. corium* var. *capitatum* Gardner (after Gardner); 13–15. *P. tenue* (Menegh.) Gom. (after Frémy); 16, 17. *P. microtomum* Skuja (after Skuja); 18, 19. *P. ceylanicum* Wille (after Wille).

### 17. **Phormidium rubroterricola** Gardner

New Myxophyceae from Porto Rico, Mem. N. Y. bot. Gdn, 7: 43, pl. 9, fig. 86, 1927; Geitler, Kryptogamenflora, 1005, fig. 643, 1932.

Pl. 43, Fig. 3

Trichome 2.2–2.4 μ broad, not constricted at the cross-walls, with straight ends; cells quadrate or somewhat longer or shorter; end-cells obtuse-conical; sheath distinct, not diffluent.

In cultures of garden soil, Allahabad (Mitra, 1951, 360).

### 18. **Phormidium bigranulatum** Gardner

Rhodora, 28: 2, 1926; Geitler, Kryptogamenflora, 1006, 1932.

Filaments 0.8–1 (–1.4) μ broad, long, seemingly straight; trichome 0.7–0.9 μ broad, not constricted at the cross-walls, at the ends bent, not capitate; cells 9–13 μ long, at each end with one granule; sheath mostly not clearly seen or only distinct at places where the trichome emerges after a break.

In the mucilage of *Schizochlamys* from a pond, Madras ( ! ).

### 19. **Phormidium bohneri** Schmidle

Beitr. z. Algenfl. Afrikas, Engler's Bot. Jahrb., 30: 59, pl. 2, fig. 11, 1901; Forti in De Toni, Sylloge Algarum, 5: 222, 1907; Frémy, Myxo. d'Afr. équat. franc., 145, fig. 128, 1929; Geitler, Kryptogamenflora, 1008, 1932.

Thallus thin, mucilaginous, green; trichome nearly straight, more or less parallel, not constricted at the cross-walls, 1.7–2 μ broad, not attenuated at the ends, not capitate, blue-green; sheath hyaline, diffluent, not coloured violet by chlor-zinc-iodide; cells mostly shorter than broad, seldom quadrate or somewhat longer than broad; end-cell rounded.

On moist soil or submerged objects.—Rangoon, Maymyo islands in Burma (Ghose, 1926, 247; 1927d, 255; 1927c, 80); Palacol and Narsapur in Andhra Pradesh (Rao, C. B., 1938a, 93).

Geitler apparently identifies it with *P. cebennense* and Forti with *P. luridum.*

Two forms of this species are known from India.

Rao (The Myxophyceae of the United Provinces, II, Proc. Indian Acad. Sci., 3: 173, 1936.) describes a form.

Filaments 1.7–2 μ broad; cells 1.5–2.1 μ long; trichome irregularly curved.

On damp wall, Benaras; on an iron water pipe and in a cement waste water drain, Berhampur (Rao, C. B., 1936, 173; 1938b, 168).

This form appears to belong to *P. cebennense.*

Rao (The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., 6: 368, 1937b.) describes a form.

Filaments 3–3.7 μ broad, filaments closely entangled with a persistent sheath; cells 2.2–2.8 μ broad, 1.6–2.8 μ long.

On a cemented surface near the waste water outlet of a house, Ramnagar in Uttar Pradesh (Rao, C. B., *loc. cit.*).

### 20. **Phormidium cebennense** Gomont

Sur Quelques Oscill. nouv., Bull. Soc. Bot. Fr., 46: 38, pl. 1, fig. 14, 1899; Frémy, Myxo. d'Afr. équat franc., 145, fig. 129, 1929; Geitler, Kryptogamenflora, 1008, 1932.

Thallus thin, expanded, golden brown; filaments flexuous, entangled or nearly parallel and straight; sheath thin, papyraceous, firm or diffluent, not coloured violet by chlor-zinc-iodide; trichome light brown, 2 μ broad, not constricted at the cross-walls, ends not attenuated, not curved; cells 1–1.5 μ long, septa not granulated; end-cell rounded, calyptra absent.

On moist or submerged stones, etc., Benaras (Rao, C. B., 1937b, 368), Polanur in Andhra (Rao, C. B., 1938a, 93), Puri and Cuttack and Berhampur in Orissa (Rao, C. B., 1938b, 168).

### 21. **Phormidium purpurascens** (Kütz.) Gomont

Essai class. Nostoc. homo., J. de Bot., Fr., 4: 355, 1890; Monogr. Oscillariées, 166, pl. 4, fig. 19, 1892; Forti in De Toni, Sylloge Algarum, 5: 223, 1907; Geitler, Kryptogamenflora, 1009, fig. 644c, 1932.

Pl. 44, Fig. 4 & Pl. 45, Figs. 1–4

Thallus compact, leathery, purple to brownish violet; trichome strongly bent, entangled, not constricted at the cross-walls, ends not attenuated, 1.5–2.5 μ broad, dark violet; sheath more or less diffluent, not coloured violet by chlor-zinc-iodide; cells nearly quadrate or up to nearly two times longer than broad, 2–4.5 μ long, cross-walls marked by two granules on either side; end-cell rounded, calyptra absent.

In a cemented water course near a tap, Cuttack and on stones in a pond, Berhampur (Rao, C. B., 1938b, 168); forming a brownish violet stratum on *Mougeotia* in Jamuna River near Allahabad (Gupta, 1956, 78).

The alga in Rao's material is slightly different (Filaments 3–4 μ broad, sheath 0.5 μ thick; trichome 2–2.5 (-2.8) μ broad; cells 2–5 μ long).

### 22. **Phormidium luridum** (Kütz.) Gomont

Monogr. Oscillariées, 165, pl. 4, figs. 17, 18, 1892; Forti in De Toni, Sylloge Algarum, 5: 222, 1907; Frémy, Myxo. d'Afr. équat. franc., 144, fig. 127, 1929; Geitler, Kryptogamenflora, 1009, fig. 645a, 1932.

Thallus membranous, on the surface purple to dark violet to blackish to blue-green and grey to blue-green on the under surface; trichome flexuous, fragile, ends not curved, not attenuated, slightly constricted at the cross-walls, 1.7–2 μ broad, light violet, septa not granulated; cells 1.8–4.7 μ long; sheath thin, diffluent, but later becoming compact, not coloured violet by chlor-zinc-iodide; end-cell rounded, calyptra absent.

Mangrove swamp, on moist soils and stagnant waters.—Pandure, Ceylon (West and West, 1902, 204); Tank Wendrankulam near Kantelai (Crow, 1923b, 142); paddy-fields, Faridpur, Gopalnagar in Bengal (Banerji, 1935, 298; 1938, 103); in soils of Benaras, Gorakhpur, Basti and Mirzapur in U.P. (Singh, R. N., 1939, 60); environs of Shembaganur in Madras State (Frémy, 1942, 21); Rangoon in Burma (Skuja, 1949, 51).

### 23. **Phormidium orientale** West, G. S.

On some Algae from Hot Springs, Journ. Bot. Lond., 40: 248, pl. 439, figs. 25–27, 1902; Forti in De Toni, Sylloge Algarum, 5: 225, 1907; Geitler, Kryptogamenflora, 1010, 1932.

Thallus very thin, blue-green; filaments more or less entangled; sheath very thin, firm; trichome 1.6–1.8 μ broad, not constricted at the cross-walls; ends straight, not capitate; cells 3 1/2–4 1/2 times as long as broad.

In Malayan Hot Springs (West, *loc. cit.*); in Vajreshwari Hot Springs (38°–49°C), Bombay (Gonzalves, 1947, 26).

### 24. **Phormidium valderianum** (Delp.) Gomont

Monogr. Oscillariées, 167, pl. 4, fig. 20, 1892; Forti in De Toni, Sylloge Algarum, 5: 222, 1907; Frémy, Myxo. d'Afr. équat. franc., 143, fig. 126, 1929; Geitler, Kryptogamenflora, 1011, fig. 645c, 1932; Frémy, Cyano. cotes d'Eur., 87, pl. 23, fig. 2, 1933.

Pl. 44, Fig. 5

Thallus lubricous, expanded, up to 3 cm. high, lamellated, outer surface dull green, inner surface colourless; trichomes flexuous, densely entangled, not constricted at the cross-walls, ends not attenuated, not curved, 2–2.5 μ broad, blue-green; sheath thin, firm, finally becoming more or less diffluent, coloured violet by chlor-zinc-iodide; cells longer than broad, 3.3–6.7 μ long, cross-walls with 1 or 2 granules on either side; end-cell rounded, calyptra absent.

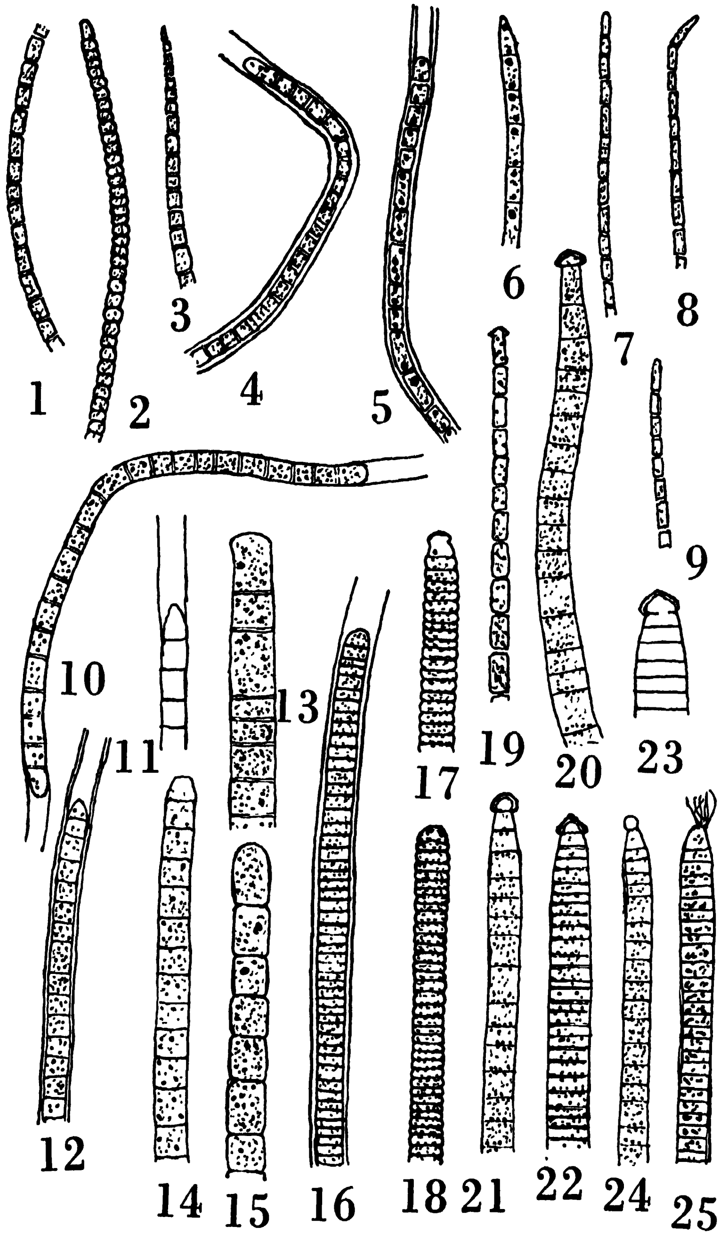

PLATE 44, Figs. 1–25.

1–3. *Phormidium fragile* (Menegh.) Gom.; 4. *P. purpurascens* (Kütz.) Gom.; 5. *P. valderianum* (Delp.) Gom.; 6. *P. laminosum* (Ag.) Gom.; 7–9. *P. tenue* (Menegh.) Gom.; 10–11. *P. corium* (Ag.) Gom.; 12. *P. incrustatum* (Näg.) Gom.; 13–15. *P. retzii* (Ag.) Gom.; 16. *P. ambiguum* Gom.; 17, 18. *P. lucidum* Kutz.; 19. *P. submembranaceum* (Ard. et Straff.) Gom.; 20, 21. *P. favosum* (Bory) Gom.; 22, 23. *P. subfuscum* Kütz.; 24, 25. *P. autumnale* (Ag.) Gom. (all after Gomont).

On mud bottom of pools, in paddy-fields, in water-logged soil and on rocks in seashore.—Mahabaleshwar and Dadar near Bombay (Schmidle, 1900b, 161); Faridpur in Bengal (Banerji, 1935, 298; 1938, 104); seashore, Vizagapatam in Andhra State (Rao, C. B., 1938a, 93); pool at the foot of Hakgala rock, Ceylon (West and West, 1902, 204).

### 25. **Phormidium mucosum** Gardner

New Myxophyceae from Porto Rico, Mem. N. Y. bot. Gdn, 7: 43, pl. 9, fig. 84, 1927; Geitler, Kryptogamenflora, 1012, fig. 646b, 1932.

Pl. 43, Figs. 6, 7

Filaments 7.2–7.8 μ broad, long, straight, or curved; trichome 2.5–3.4 μ broad, not constricted at the cross-walls, ends; sheath apparently thick, more or less gelatinous, colourless, unlamellated; cells 2–2$\frac{1}{3}$ times as long as broad, pale blue-green; end cell rounded.

Type not recorded.

### Var. **arvense** Rao, C. B.

The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 370, fig. 7D, E, 1937b.

Plant mass thick, fragile, blue-green to greyish blue; filaments loosely entangled, 3.2–5.2 μ broad; sheath thick, firm, hyaline, unstratified, up to 2 μ thick; trichomes of uniform width, not constricted at the joints, 1.8–2.5 μ broad; apical cells with rounded apices, without calyptra or cap cells; cells quadratic or almost quadratic or slightly longer than broad, 1.5–3.6 μ long.

In stagnant rainwater of a crop-field, Benaras (Rao, C. B., *loc. cit.*).

### 26. **Phormidium stagnina** Rao, C. B.

The Myxophyceae of the Madras Presidency, I, J. Indian bot. Soc., 17: 93, figs. 4–7, 1938a.

Pl. 45, Figs. 16–18

Thallus soft blue-green and membranous; filaments 12–8–14.4 μ broad; trichome blue-green, interwoven and not attenuating, 8–9.6 μ broad; sheath hyaline, unstained by chlor-zinc-iodide, thick, firm, sometimes diffluent; cells small, without constrictions at the joints, 1.3–2 μ long; end cell broadly rounded with a prominent calyptra.

In stagnant ponds, Palacol in Andhra State (Rao, C. B., *loc. cit.*).

### 27. **Phormidium anomala** Rao, C. B.

The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 371, fig. 7F-I, 1937b.

Pl. 45, Figs. 11–13

Thallus thick expanded, soft, mucilaginous, deep blue-green, 3–6 mm thick; trichome subparallel of uniform width, 8–10 μ (–10.5) μ broad without constrictions at the cross-walls; sheath thin, colourless, not stained by chlor-zinc-iodide, persistant or dissolved; cells disc-shaped, much broader than long, 0.8–1.2 (–2) μ long; end cells bluntly rounded without cap or calyptra.

On the plinth of a college building near the outlet of a drain, Benaras (Rao, C. B., *loc. cit.*); on bricks near water tap, Berhampur (Rao, C. B., 1938b, 169).

### 28. **Phormidium ambiguum** Gomont

Monogr. Oscillariées, 178, pl. 5, fig. 10, 1892; Forti, in De Toni, Sylloge Algarum, 5: 240, 1907; Frémy, Myxo. d'Afr. équat. franc., 156, fig. 137, 1929; Geitler, Kryptogamenflora, 1015, fig. 647e, 1932; Frémy, Cyano. cotes d'Eur., 91, pl. 24, fig. 1, 1933.

Pl. 44, Fig. 16 & Pl. 45, Figs. 5–8

Thallus more or less expanded, bright blue-green, dark or yellowish green; filaments flexuous, variously entangled; trichomes slightly constricted at the cross-walls, at the ends not attenuated, not capitate, 4–6 μ broad, blue-green; sheath thin, firm or diffluent sometimes thick and more or less lamellated, coloured violet by chlor-zinc-iodide; cells shorter than broad, 1.5–2.7 μ long, rarely granulated at the cross-walls, sometimes with gas-vacuoles; end cell rounded, calyptra absent.

On submerged objects and on soil. — Ceylon (Ferguson in Gomont, 1892, 178); Rangoon and Maymyo islands in Burma (Ghose, 1927a, 222; 1927d, 255; 1927e, 80; Skuja, 1949, 50); Lahore in Pakistan (Singh, H. D., 1933, 106); Benaras (Rao, C. B., 1936, 173), Calcutta (Banerji, 1938, 105), swamp near Nalbari, Kamrup in Assam (Parukutty, 1939, 235), Nettayam in Travancore (Parukutty, 1940, 122); in rice-field soil, Siwait near Allahabad (Mitra, 1951, 359/360).

The cells in the Travancore alga are very long (3–3.3 μ).

Rao, C. B. (1937b, 369) reports from Benaras a form growing on the sides of a cemented water reservoir. This differs from the type only in the slightly narrower trichomes (about 3.4 μ broad).

#### Var. **major** Lemmermann

Kryptogamenflora der Mark Brandenburg, 3: 127, 1910; Geitler, Kryptogamenflora, 1015, 1932.

Trichomes 9.5 μ broad, bright blue-green; cells 2.5–3.5 μ long, cross-walls granulated.

On mud at Kurla near Bombay (Dixit, 1936, 104).

### 29. **Phormidium subincrustatum** Fritsch et Rich

Trans. roy. Soc. S. Afr., 18: 82, fig. 27 J–L, 1929; Geitler, Kryptogamenflora, 1016, 1932.

Thallus 2–3 mm thick, calcified; filaments more or less parallel, not erect; sheath thin, shiny, not lamellated; often not diffluent; trichomes 5–6.5 μ broad; ends not attenuated, not constricted at the cross-wall; end cell rounded or slightly conical, not capitate, calyptra absent.

On moist soil, Benaras (Rao, C. B., 1937b, 369).

Rao, C. B. (*loc. cit.*) gives the full dimensions of the alga — trichomes 4.7–5.8 sheath up to 6.5 μ; cells 2.5–8 μ long.

### 30. **Phormidium pachydermaticum** Frémy

Myxo. d'Afr. équat. franc., 156, fig. 138, 1929; Geitler, Kryptogamenflora, 1014, fig. 648b–e, 1932.

Pl. 43, Figs. 8–10

Thallus outer surface dull blue-green, inside brown; filaments 6–10 μ broad, straight or undulating; sheath at first thin, later thick, irregularly lamellated, lamellae short, irregularly disposed, outside more or less rough, not coloured blue by chlor-zinc-iodide; trichome blue-green, 5–6 μ broad, not constricted at the cross-walls, ends straight, not attenuated, not capitate; cells nearly quadrate or up to $\frac{1}{2}$ as long as broad, septa not granulated; end cell slightly convex or obtuse conical, with slightly thickened outer membrane.

Type not recorded.

Rao (The Myxophyceae of the Orissa Province, Proc. Indian Acad. Sci., B, 8: 168, 1938b.) describes a form.

Trichome 3.2–4.2 μ broad, cells longer than broad, 4–8 μ long.

On the wet steps of a tank, Berhampur (Rao, C. B., *loc. cit.*).

### 31. **Phormidium calcicola** Gardner

New Myxophyceae from Porto Rico, Mem. N. Y. bot. Gdn, 7: 44, pl. 9, fig. 87, 1927; Geitler, Kryptogamenflora, 1013, fig. 646a, 1932.

Pl. 43, Figs. 4, 5

Thallus thick, firm, with densely entangled filaments; filaments 7–8 μ broad; sheath thick, colourless, unlamellated; trichomes 5.8–6.4 μ broad, not constricted at the cross-walls, not attenuated; cells quadratic or slightly longer than broad, or shorter, blue-green; end cell truncated rounded, with a thickened outer membrane.

On the rocks in a water course, Nattayam, Travancore (Parukutty, 1940, 122).

### 32. **Phormidium retzii** (Ag.) Gomont

Essai class. Nostoc. homo., J. de Bot., Fr., 4: 355, 1890; Monogr. Oscillariées, 175, pl. 5, figs. 6–9, 1892; Forti, in De Toni, Sylloge Algarum, 5: 241, 1907; Frémy, Myxo. d'Afr. équat. franc., 152, fig. 135, 1929; Geitler, Kryptogamenflora, 1012, fig. 647, 1932. *non* Kütz.

= *Phormidium papyrinum* Kütz., Phyc. germ., 195, 1843.

Pl. 44, Figs. 13, 15

Thallus bright blue-green to dark lead colour thick, compact, penicillate or branched tufts, attached at the base, upper portions floating; filaments more or less straight, mostly unconstricted at the cross-walls, or seldom torulose, not attenuated at the ends, not capitate, straight, 4.5–12 μ broad, dull blue-green; sheath thin, firm or mostly diffluent, not coloured violet by chlor-zinc-iodide; cells shorter or longer than broad, 4–9 μ long, septa not granulated; end scarcely attenuated, end cells truncated, with a thickened outer membrane, calyptra absent.

On rocks near streams, on submerged objects, ponds, lakes etc. and on soil.—Boronga island, Arraccan Burma (Martens, 1871b, 462; also Theobald, 1883, 24) and Maymyo islands and Rangoon in Burma (Skuja, 1949, 51); Ponsonby Spring, Parel near Bombay (Schmidle, 100b, 161), Benaras and Latifshah Gorakhpur, Basti and Mirzapur (Rao, C. B., 1937b, 369; Singh, R. N., 1939a, 60); Cuttack and Berhampur (Rao, C. B., 1938b, 163), Polamur in Andhra (Rao, C. B., 1938a, 93), Patna (Rao, C. B., 1939, 149), Gauhati (Parukutty, 1939, 234), Pallichal, Perukada and Nedumangad in Travancore (Parukutty, 1940, 122) and Shembaganur in Madras (Frémy, 1942, 21); in tank at Kekunadure near Matara in Ceylon (Crow, 1923b, 142).

Geitler thinks this is made up of a number of species.

#### forma **major** Parukutty

Myxophyceae of the Travancore State, Proc. Indian Acad. Sci., B, 11: 122, 1940.

Filaments 6.6–10.5 μ broad, cells 3.6–9.9 μ long.

Growing on soil, Trivandrum and its environs (Parukutty, *loc. cit.*).

### 33. **Phormidium hieronymusii** Lemmermann

Das Plankton Schwedischer Gewässer, Ark. f. Bot., 2: 104, 1903/4; Abh. nat. ver. Bremen, 14: 259, pl. 1, figs. 5–7; Kryptogamenflora der Mark Brandenburg, 3: 128, 1910; Geitler, Kryptogamenflora, 101, 193.

Thallus dull olive-green; trichome more or less regularly spirally coiled, not constricted at the cross-walls, distinctly attenuated at the ends, 7 μ broad, dull blue or yellow-green; sheath thin, firm, not coloured violet by chlor-zinc-iodide; cells very short, 1.5–2 μ long, cross-walls often granulated; end cell rounded, seldom slightly capitate.

Type not recorded.

Mitra (1951, 359, 360, 362) records a new form from paddy-field soil near Allahabad and from red soil from Vandalur near Madras (f. *major, nomem nudum*).

### 34. **Phormidium incrustatum** (Näg.) Gomont

in Bornet and Flahault, Sur quelques plantes vivant dans le test calcaire des Mollusques, Bull. Soc. bot. Fr., 36: 154, 1889; Monogr. Oscillariées, 170, pl. 4, fig. 27, 1892; Forti, in De Toni, Sylloge Algarum, 5: 230, 1907; Geitler, Kryptogamenflora, 1017, fig. 649a, 1932.

Pl. 44, Fig. 12

Thallus brownish-red or violet, with calcium incrustation, very hard; trichome entangled or erect and parallel, not constricted at the cross-walls, 4–5 μ broad; ends briefly attenuated, erect, not capitate; sheath thin, mucilaginous, not coloured violet by chlor-zinc-iodide; cells nearly quadrate, 3.5–5.2 μ long, cross-walls generally invisible sometimes granulated; end cells obtuse-conical, calyptra absent.

Attached to a decaying log of wood in a tank, Somastipur, Bihar (Rao, C. S., 1939, 150).

The Bihar alga differs much from the type (filament 4–5 μ broad, trichome 2.5–3 μ broad, cells 2.8–5.6 μ long).

### 35. **Phormidium corium** (Ag.) Gomont

Essai class. Nostocacées homocystées, J. de Bot. Fr., 4: 355, 1890; Monogr. Oscillariées, 172, pl. 5, fig. 1, 2, 1892; *non* Kützing *nec* Rabenhorst; Forti in De Toni, Sylloge Algarum, 5: 235, 1907; Frémy, Myxo. d'Afr. équat. franc., 150, fig. 133, 1929; Geitler, Kryptogamenflora, 1018, fig. 649, b, c, 1932; Frémy, Cyano. cotes d'Eur., 89, pl. 23, fig. 6, 1933.

Pl. 44, Figs. 10–11

Thallus expanded, membranous, leathery, blackish to brownish green; filaments long, more or less flexuous, densely entangled; sheath thin, gelatinizing

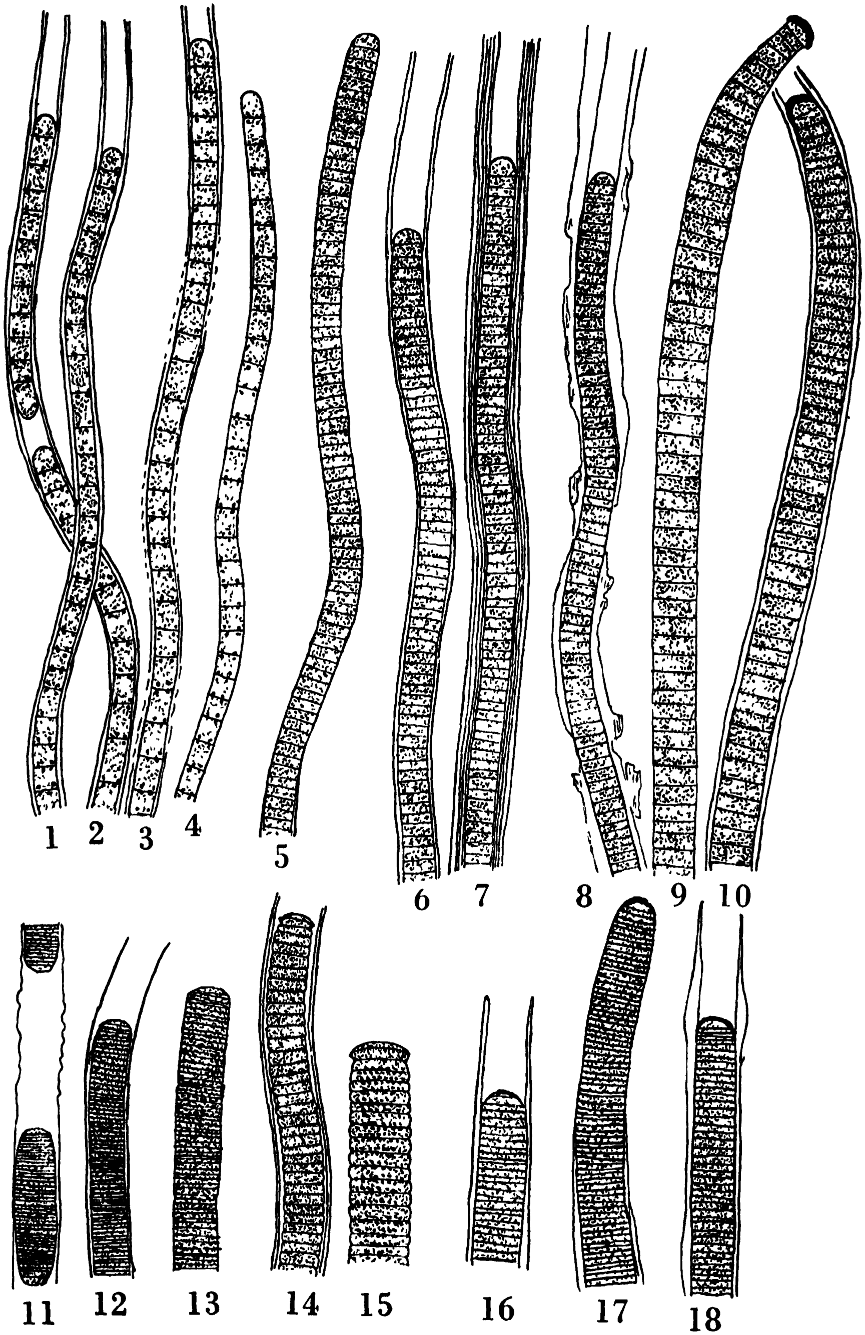

PLATE 45, Figs. 1–18.

1–4. *Phormidium purpurascens* (Kütz.) Gom. (after Frémy); 5-8. *P. ambiguum* Gom. (after Frémy); 9–10. *P. uncinatum* (Ag.) Gom. (after Frémy); 11–13. *P. anomala* Rao, C. B. (after Rao); 14, 15. *P. rotheanum* v. *captitatum* var. nov. (after Skuja); 16–18. *P. stagnina* Rao, C. B. (after Rao).

or diffluent, coloured violet by chlor-zinc-iodide; trichome blue-green, not constricted at the cross-walls, ends straight, briefly attenuated, not capitate, 3–4.5 μ broad; cell nearly quadrate, up to twice as long as broad, 3.4–8 μ long, not granulated at the cross-walls; end-cell obtuse conical, calyptra absent.

On moist soils, walls etc., in paddy fields, floating in aestuarine areas.—Rambha Bay, Chilka lake and Berkuda island (Biswas, 1924, 363; 1932b, 187), Cuttack (Rao, C. B., 1938b, 168), Faridpur in Bengal (Banerji, 1935, 198), Narsapur and Palacol in Andhra (Rao, C. B., 1938a, 94); Shillong (Parukutty, 1939, 235), Palode in Travancore (Parukutty, 1940, 122); on moist dripping walls after heavy rains, Madras ( ! ).

Mitra (1951, 355/360) describes a forma *terrestris* (*nomen nudum*) which he isolated from cultures of soil from rice-fields and uncultivated fields near Allahabad.

### Var. **capitatum** Gardner

Univ. Calif. Publ. Bot., 14: 4, pl. 1, fig. 1, 1927; Geitler, Kryptogamenflora, 1019, 1932.

Pl. 43, Figs. 11–12

Sheath thin, firm and smooth; trichomes 5.2–6.4 μ broad, not constricted at the cross-walls, pale blue-green; end cell round or obtuse conical, with distinctly thickened outer membrane.

On stones in a channel, Berhampore (Rao, 1938b, 169).

The Berhampore alga is narrower (4.8–5.4 μ broad, cells 3.8–6.8 μ long).

### 36. **Phormidium inundatum** Kützing ex Gomont

Kützing, Species Algarum, 251, 1849; Gomont, Monogr. Oscillariées, 172, pl. 4. figs. 31–32, 1892; Forti in De Toni, Sylloge Algarum, 5: 232, 1907; Frémy, Myxo. d'Afr. équat. franc., 149, fig. 132, 1929; Geitler, Kryptogamenflora, 1019, fig. 649e, 1932.

Thallus dark blue-green, membranous; filaments suberect, when dry fragile, sheath thin, becoming diffluent, coloured violet by chlor-zinc-iodide; trichome blue-green, straight or bent, not constricted at the cross-walls, ends straight, briefly attenuated, not capitate, 3–5 μ broad, cells nearly quadrate or longer than broad, 4–8 μ long, granulated at the septa, end cell obtuse conical, calyptra absent.

On walls and in fresh water situations. — Henzadah in Burma (Theobald, 1883, 24); Bombay (Schmidle, 1900b, 162) and Trivandrum (Parukutty, 1940, 122).

### 37. **Phormidium papyraceum** (Ag.) Gomont

Essai class Nostocacées homocystées, Morots J. Bot., 4: 355, 1890; Monogr. Oscillariées, 173, pl. 5, figs. 3 and 4, 1892; Forti in De Toni, Sylloge

Algarum, 5: 237, 1907; Frémy, Myxo. d'Afr. équat. franc., 151, fig. 134, 1929; Geitler, Kryptogamenflora, 1020, fig. 650a, b, 1932.

Thallus dark green, glistening, expanding, thin, leathery, when dry fragile; filaments elongate, very flexuous, densely entangled; sheath thin, papery, persistent, sometimes diffluent, coloured violet by chlor-zinc-iodide; trichomes blue-green, not constricted at the cross-walls, 3–5 μ broad; ends straight, briefly attenuated, not capitate; cells subquadrate or mostly shorter than broad, 2–4 μ long; cross-walls conspicuous, not granulated, end cell obtuse conical, calyptra absent.

Poona (Schmidle, 1900b, 162), on the barks of trees, Puri (Rao, C. B., 1938b, 169), Shembaganur (Frémy, 1942, 21), in the river Hooghly, Calcutta (Biswas, 1941, 199).

The cells in the Puri alga are longer ( (2–) 4.2–5 μ long).

### 38. **Phormidium ceylanicum** Wille

Süsswasseralgen von den Samoainseln, Hawaii, den Solomoninseln und Ceylon, in Rechinger, Denkschr. Akad. Wiss. Wien, math-naturw. Kl., p. 162, pl. 3, figs. 30–33, 1915; Geitler, Kryptogamenflora, 1021, fig. 650c, 1932.

Pl. 43, Figs. 18, 19

Thallus olive blue-green, or dull green, flat; sheath diffluent, in a homogeneous mucilage, not coloured violet by chlor-zinc-iodide; trichome blue-green, straight, slightly constricted at the cross-walls, ends gradually tapering, not capitate, 7–9 μ broad; cells as long as broad or 1/2–1/3 times as long; end cell more or less pointed by conical, calyptra absent.

Amidst moss on trees, Waldern, Ceylon (Wille, *loc. cit.*).

### 39. **Phormidium hansgirgi** Schmidle

Allg. bot. Zeitschr., 78, 1900a, Hedwigia, 39: 187, 1900b; Forti in De Toni, Sylloge Algarum, 5: 235, 1907; Geitler, Kryptogamenflora, 1022, 1932.

Thallus lamellated, lamellae thick, papery, when dry fragile; filaments densely entangled or aggregated, parallel mostly straight, long, 12–16 μ broad; sheath mucilaginous, about 2 μ thick, not lamellated, at first hyaline later becoming light brown, coloured violet by chlor-zinc-iodide; trichome cylindrical, 10–12 μ broad, apical cell conical acuminate, not capitate, blue-green; cells short 1–2 μ long; rectangular, contents homogeneous, slightly granular; hormogones short, few-celled.

On the tree trunks, Poona and near Bombay (Schmidle, *loc. cit.*); Lahore (Ghose, 1919, 10).

### 40. **Phormidium subfuscum** Kütz. ex Gomont

Kützing, Phyc. gene., 195, 1843; Gomont, Monogr. Oscillariées, 182, pl. 5, figs. 17–20, 1892; Forti in De Toni, Sylloge Algarum, 5: 247, 1907; Frémy, Myxo. d'Afr. équat. franc., 161, fig. 141, 1929; Geitler, Kryptogamenflora, 1022, figs. 652 d–g, 1932; Frémy. Cyano. cotes d'Eur., 92, pl. 23, fig. 8, 1933.

Pl. 44, Figs. 22, 23

Thallus very much expanded, ragged, dark-green or dark olivaceous, thin lamellated; filaments straight, fragile, short, parallel; sheath diffluent into a lamellose mucuous, not coloured violet by chlor-zinc-iodide; trichome pale blue-green or olive-green, 5.5–11 μ broad, not constricted at the cross-walls; cells 1/2–1/4 as long as broad, rarely subquadrate, 2–4 μ long, cross-walls often granulated; ends more or less briefly attenuated, capitate; end cells straight, acute-conical.

On damp soil or in standing waters. — Rangoon (Ghose, 1927e, 80); Benaras (Rao, C. B., 1937b, 369).

Var. **luteo-fuscescens** Rabenh.

Fl. Eur. Alg., 2: 125, 1865; Forti in De Toni, Sylloge Algarum, 5: 249, 1907.

= *Oscillaria subfusca* Vaucher, Hist. des Conf., 193, pl. 15, fig. 5, 1903.

Thallus yellowish, trichome about 6 μ broad.

At the waterfalls, Maharajpur, Rajmahal Hills (Martens, 1870a, 11).

Var. **joannianum** (Kütz.) Gomont

Monogr. Oscillariées, 184, 1892; Forti in De Toni, Sylloge Algarum 5: 248, 1907; Geitler, Kryptogamenflora, 1022, 1932.

Trichomes 5.5–7 μ broad, ends commonly long, attenuated.

In standing water or on damp soil, Rangoon, Burma (Ghose, 1926, 246).

### 41. **Phormidium submembranaceum** (Ard. et. Straff) Gomont

Gomont, Monogr. Oscillariées, 180, pl. 5, fig. 13, 1892; Forti in De Toni, Sylloge Algarum, 5: 244, 1907; Geitler, Kryptogamenflora, 1023, fig. 652, o, 1932. Frémy, Cyano. cotes d'Eur., 91, pl. 24, fig. 2, 1933.

Thallus membranous, leathery, dull green; trichomes without sheath, densely entangled, in an amorphous mucilage, mucilage not coloured violet by chlor-zinc-iodide; constricted at the cross-walls, 5 μ broad, ends straight, gradually or long attenuated, capitate; cells subquadrate to twice as long as broad, 4–10 μ long; apical cell with a somewhat depressed rounded calyptra.

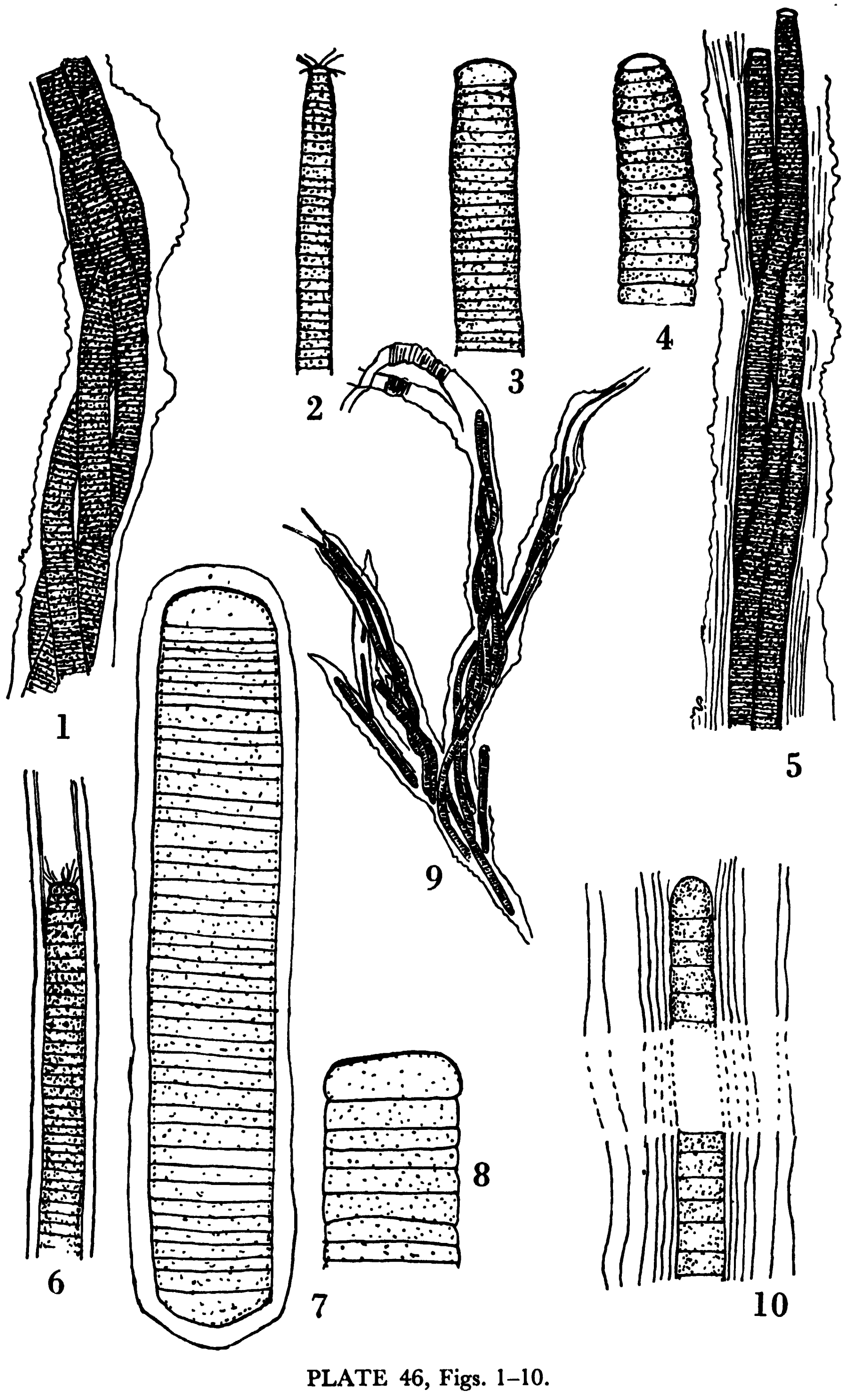

PLATE 46, Figs. 1–10.

1, 2, 6. *Hydrocoleum lyngbyaceum* Kütz. (after Gomont); 3, 9. *H. heterotrichum* Kütz. (after Gomont); 4, 5. *H. cantharidosmum* (Mont.) Gom. (after Gomont); 7, 8. *Crinalium magnum* Fritsch et John (Fritsch & John); 10. *Polychlamydum varium* Ghose (after Ghose).

On the lower face of rocks and boulders near the pier at Berkuda island (Biswas, 1932b, 187); on sponge *Laxodermites suberites* ( ? ) and a polyzoan, *Bimaria fluminalis* (Biswas, 1936, 121).

Pl. 44, Fig. 19

Biswas (1932b, 187) gives the diameter of the trichome as 6 μ.

### 42. **Phormidium favosum** (Bory) Gomont

Monogr. Oscillariées, 180, pl. 5, figs. 14–15, 1892; Forti in De Toni, Sylloge Algarum, 5: 245, 1907; Frémy, Myxo. d'Afr. équat. franc., 160, fig. 140, 1929; Geitler, Kryptogamenflora, 1024, figs. 652a, b, 1932; Frémy, Cyano. cotes d'Eur., 91, pl. 24, fig. 3, 1933.

Pl. 44, Figs. 20, 21

Thallus dark blue-green, when dried dark steel-blue coloured, generally a little expanded, papery attached to the base; trichomes mostly without sheath in an amorphous mucilage, mucilage not coloured blue with chlor-zinc-iodide; blue-green, elongate, more or less flexuous, not constricted at the cross-walls, (4–) 4.5–9 μ broad, ends straight or loosely spirally coiled, gradually attenuated, capitate; cells quadrate to up to 1/2 as long as broad, 3–7 μ long, cross-walls granulated, end cell obtuse truncated, calyptra subhemispherical.

On mud in a drain, Cuttack (Rao, C. B., 1938b, 169); Univ. Estate, Rangoon in Burma (Skuja, 1949, 50).

Rao, C. B. (1937b, 369) describes a form growing on the sides of a big water reservoir, Benaras — trichome 4–6 μ broad, cells 2.4–3.5 μ long. It does not appreciably differ from the type.

### 43. **Phormidium lucidum** Kützing ex Gomont

Kützing, Phyc. gene., 194, 1843; Gomont, Monogr. Oscillariées, 179, pl. 5, fig. 11–12, 1892; Forti in De Toni, Sylloge Algarum, 5: 243, 1907; Frémy, Myxo. d'Afr. équat. franc., 159, fig. 139, 1929; Geitler, Kryptogamenflora, 1025, figs. 648f–h, 1932.

Pl. 44, Figs. 17, 18

Thallus firm, thick, upper surface dull green, inner portion more or less colourless; filaments somewhat flexuous, sub-parallel; sheath diffluent, not coloured violet by chlor-zinc-iodide; trichome olivaceous, slightly constricted at the cross-walls, 7–8 μ broad; ends straight and more or less attenuated, often mucronate, capitate; cells 1/2–1/4 as long as broad, 2–2.5 μ long, cross-walls granulated; end cell with a rotund or subconical calyptra.

Stagnant water at Lovedale near Jog ( ! ).

Skuja (1949, 50) describes a form from Rangoon growing in a laboratory aquarium. — Filaments 9–11 μ broad, slightly bent, parallel, with colourless diffluent sheath, forming a blue-green, membranous thallus; trichome 5.5–7.5 μ broad, ends not attenuated or only briefly attenuated, distinctly constricted at the cross-walls, in older parts up to 9–11 μ, prominently swollen; cells 1/2–1/4 as long as broad, not granulated or indistinctly granulated, contents homogeneous or finely granulated; end cells only seldom somewhat capitate, but rounded with a thickened membrane.

The form is characterised by the broader trichome and the characteristic end cells.

### 44. **Phormidium uncinatum** (Ag.) Gomont

Essai class. Nostocacées Homocystées, Morot's J. de Bot., 4: 355, 1890; Monogr. Oscillariées, 184, pl. 5, figs. 21 and 22, 1892; Forti in De Toni, Sylloge Algarum, 5: 250, 1907; Frémy, Myxo. d'Afr. équat. franc., 163, fig. 142, 1929; Geitler, Kryptogamenflora, 1025, figs. 652h, i, 1932; Frémy, Cyano. cotes d'Eur., 94, pl. 24, fig. 5, 1933.

= *Oscillaria antliara* d. *physoides* Rabenhorst, F. Eur. Alg., 2: 101, 1865.

= *Lyngbya rupestris* Ag. in Turner, The Freshwater Algae of East India, K. Sv. Vet. Akad. Handl., 25: 13, 1892. *non* Agardh 1824, *non* Crouan 1865.

Pl. 43, Figs. 1, 2 & Pl. 45 Figs. 9, 10

Stratum broadly expanded, dark green to brownish black, adherent, thin, firm, or floating attached at the base, thick, torn; filaments straight or slightly bent, sheath mucilaginous, distinct or diffluent in an amorphous mucilage, not coloured blue by chlor-zinc-iodide; trichome blue-green, not constricted at the cross-walls, 6–9 μ broad, ends briefly attenuated, capitate, curved or short spirally coiled; cells 1/2–1/3 as long as broad, rarely subquadrate, 2–6 μ long, cross-walls frequently granulated; end-cell with a round or depressed conical calyptra.

In brackish swamps, Akyab (Zeller, 1873b, 177); in soils Lahore (Singh, H. D., 1933, 106), Shembaganur (Frémy, 1942, 21), Red soil, Vandalur near Madras (Mitra, 1951); freshwater algae, N. India (Turner, 1892, 13).

### 45. **Phormidium autumnale** (Ag.) Gomont

Monogr. Oscillariées, 187, pl. 5, figs. 23 and 24, 1892; Forti in De Toni, Sylloge Algarum, 5: 252. 1907; Frémy, Myxo. d'Afr. équat. franc., 164, fig. 143, 1929; Geitler, Kryptogamenflora, 1026, figs. 652k, l, and 653a, 1932; Frémy, Cyano. cotes d'Eur., 93, pl. 24, fig. 4, 1933.

= *Oscillaria antilaria* Mert., in Jürgens, Alg. aquat., Dec. 14, n. 4, 1822; Agardh, Syst. Alg., 63, 1824.

Pl. 44, Figs. 24, 25

Thallus expanded, dark blue-green or brownish-green, sometimes yellowish or violet, filaments straight, rarely flexuous, variously entangled; sheath firm, mucilaginous, distinct or diffluent in an amorphous mucilaginous matrix, not coloured blue by chlor-zinc-iodide; trichomes blue-green, not constricted at the cross-walls, 4–7 μ broad, ends mostly briefly attenuated, rarely gradually attenuated, straight or scarcely curved, prominently capitate; cells quadrate or 1/2 as long as broad, 2–5 μ long, septa frequently granulated, end cell with a rounded or truncated conical calyptra.

On submerged objects, on muddy banks of tanks and rivers.— Calcutta (Martens, 1870b, 259; Prain, 1905, 330; Biswas, 1949, 50); Benaras (Rao, C. B., 1937b, 371); Narsapur in Andhra (Rao, C. B., 1938a, 94); in wheat and paddy-field soils, Usar soils, uncultivated fields, Allahabad (Mitra, 1951, 359, 360, 362); Rangoon in Burma (Zeller, 1873; Skuja, 1949, 50); Lahore in Pakistan (Ghose, 1924, 338).

Rao, C. B. (1938b, 169) describes a form growing on a moist pavement near a water tap at Khurda Road in Orissa. It differs from the type in having shorter cells (trichome 4–5 μ broad, at the apex 4 μ broad, cells 1–2 μ long).

## SPECIES INQUIRENDAE

### **Phormidium moerlianum** Grun.

in Rabenhorst, Fl. Eur. Alg., 2: 127, 1865; Forti in De Toni, Sylloge Algarum, 5: 236, 1907.

Thallus pale brown, mucilaginous, less compact; trichomes a little curved, brownish, rarely blue-green, 9–12 μ broad; cells $\frac{1}{2}$–$\frac{1}{4}$ as long as broad, cross-walls granulated, apex erect, round; sheath thin, adherent, colourless.

In stagnant water with decaying vegetable matter, Lahore in Pakistan (Ghose, 1919, 10).

This species is not well known and is placed under 'species inquirendae' (cf. Gomont, 1892, 191).

### **Phormidium oryzetorum** Martens

A third list of Bengal Algae, Proc. Asiatic Soc., Bengal, 39: 12, 1870a. A list of algae collected by Mr. S. Kurz in Burma etc., *ibid*, 40· 463, 1871b.

Thallus membranous, thin, green, filaments narrow, flexuous, bluish, cells 1.25 μ diam., short.

Inundated rice-fields, Calcutta (Martens, 1870, 12); floating in stagnant tanks and submerged rice-fields, Arracan (Martens, 1871b, 463).

According to Kurz, this is the most common alga in Lower Bengal, coming in large spongy patches in ponds, rice-fields etc. and adding much towards a natural manure of the fields.

This species has not been reported again.

### **Phormidium solitare** (Kütz.) Rabenh.

Fl. Eur. Alg., 2: 127, 1865; Forti in De Toni, Sylloge Algarum, 5: 236, 1907.

Filaments sparse or a few forming a thin pale blue-green stratum, intricate; trichomes rigid, flexuous, light blue-green, 5–7.8 μ broad, $\frac{1}{3}$–$\frac{1}{4}$ as long as broad, septa finely granulated, apical cell obtuse.

On dead and living plants in a tank (Martens, 1870b, 258; Prain, 1905, 333).

Gomont (1892) includes this species under 'species inquirendae'.

## LYNGBYA Ag.

Syst. Alg., 25, 1824: Gomont, Monogr. Oscillariées, 118, 1892.

Trichome single or free in a thin or very massive thick, firm sheath; sheath mostly colourless, seldom coloured yellow to brown or red, blue to purple red; filaments sometimes spirally coiled or attached at the base or in the middle or the entire filament attached, mostly without such attachment or free-swimming or forming free thallus.

Type species: *Lyngbya confervoides* Ag.

The genus is generally divided into four sections — *Spirocoleus, Heteroleibleinia, Leibleinia* and *Eulyngbya.* Crow (Trans. Amer. micr. Soc., 46 (2): 139–148, 1927) suggested the retention of the genus *Spirocoleus* Moebius to include all the spiral, sheathed forms now included under *Lyngbya.*

### KEY TO THE SPECIES

1. Filaments erect, attached by the base .................................. 2
1. Filaments not so attached .................................. 6
    2. Filaments very short, up to 30 μ long, 1.3 μ broad 1. *L. chaetomorphae* (p. 281)
    2. Filaments otherwise .................................. 3
3. Trichomes broader than 2 μ.................................. 4
3. Trichomes narrower.................................. 5
    4. Trichomes constricted 2.5–3.5 μ broad, .......... 2. *L. lachneri* (p. 281)
    4. Trichomes unconstricted, 2.5–3.5 μ broad, cross-walls with single granules on either side .......................... 3. *L. mesotricha* (p. 282)
5. Trichome 1.8–2 (–2.3) μ broad, marine .................. 4. *L. infixa* (p. 282)
5. Trichome short, 1.5–2 μ broad, unconstricted, cells $\frac{1}{3}$–$\frac{1}{2}$ as long as broad 5. *L. kuetzingii* (p. 282)
5. Trichome up to 2 mm long, 1.3–1.6 μ broad, slightly constricted, cells quadrate or longer or shorter than broad ...................... 6. *L. gardeneri* (p. 284)
    6. Filaments attached by the middle with the ends free or by their entire length .................................. 7
    6. Filaments not attached by any regular manner, free or epiphytic, or in the mucilage of other algae .................................. 14

7. Creeping other algae ...... 7. *L. epiphytica* (p. 284)
7. Filaments not so ...... 8
   8. Trichomes 14–31 μ broad, marine ...... 8. *L. sordida* (p. 285)
   8. Trichomes narrower ...... 9
9. Trichome narrower than 5μ ...... 11
9. Trichome broader than 5 μ ...... 10
   10. Trichomes 8–11 μ broad ...... 9. *L. baculum* (p. 285)
   10. Trichomes 5–8.5 μ broad ...... 10. *L. gracilis* (p. 285)
11. Trichome 3–4.5 μ broad, marine ...... 11. *L. holdenii* (p. 286)
11. Trichome narrower ...... 12
   12. Trichome up to 60 μ long ...... 12. *L. distincta* (p. 286)
   12. Trichome longer ...... 13
13. Trichome up to 200 μ long, cells ½–⅓ as long as broad 13. *L. polysiphoniae* (p. 287)
13. Trichome longer, cells 1–1½ times as long as broad ...... 14. *L. nordgardhii* (p. 287)
   14. Filaments more or less regularly spirally coiled ...... 15
   14. Filaments not spirally coiled ...... 21
15. Filaments about 10 μ or broader ...... 17
15. Filaments narrower than 10 μ ...... 16
   16. Trichomes 4.5–5 μ broad ...... 15. *L. spiralis* (p. 289)
   16. Trichomes up to 2.5 μ broad ...... 18
17. Trichomes 8.5–9.5 μ broad ...... 16. *L. laxespiralis* (p. 289)
17. Trichomes 14–16 μ broad ...... 17. *L. spirulinoides* (p. 289)
   18. Cells longer than broad ...... 19
   18. Cells shorter or slightly longer than broad ...... 20
19. Cells 1–1.5 μ broad, 3.5–5.5 μ long, loosely spirally coiled, with a granule at the cross-walls ...... 18. *L. bipunctata* (p. 290)
19. Cells 1–2 μ broad, 3–5 μ long, regularly coiled without granules 19. *L. contorta* (p. 290)
   20. Cells about 2 μ broad, 1.2–3 μ long, spirally coiled, sometimes straight 20. *L. lagerheimii* (p. 290)
   20. Cells 1.8–2.1 μ broad, 1–2 μ long, spirally and circularly coiled 21. *L. circumcreta* (p. 291)
21. Filaments in the mucilage of other algae ...... 22
21. Filaments not so ...... 23
   22. Cells 0.5–0.8 μ broad, cross-walls not granulated . 22. *L. rivularianum* (p. 293)
   22. Cells 0.5 μ broad, cross-walls with a single granule on either side 23. *L. mucicola* (p. 293)
23. Filaments free-floating ...... 24
23. Filaments among other algae ...... 29
   24. Filaments narrower than 5 μ broad ...... 25
   24. Filaments broader ...... 27
25. Filaments 1–2 μ broad ...... 26
25. Filaments 2.6–5 μ broad ...... 24. *L. borgerti* (p. 293)
   26. Trichomes 1–1.5 μ broad ...... 25. *L. limnetica* (p. 294)
   26. Trichomes 1.5–1.8 μ broad ...... 26. *L. subtilis* (p. 294)
27. Filaments 20–24 μ broad ...... 27. *L. birgei* (p. 296)
27. Filaments narrower ...... 28
   28. Filaments 11.5–12.5 μ broad ...... 28. *L. shackletoni* (p. 296)
   28. Filaments 12–14 (–15–20) μ broad ...... 29. *L. hieronymusii* (p. 297)
   28. Filaments 4–9 μ broad ...... 30. *L. cryptovaginata* (p. 297)

29. Mature plants with coloured sheaths ........ 30
29. Mature plants with hyaline sheaths ........ 41
30. Sheath yellow to brown ........ 32
30. Sheath red ........ 31
30. Sheath blue to purple ........ 31. *L. kashyapii* (p. 298)
31. Trichomes 4–5 μ broad ........ 32. *L. rubida* (p. 298)
31. Trichomes 8–12 μ broad ........ 33. *L. ceylanica* (p. 299)
32. Trichome up to 4 μ broad ........ 33
32. Trichomes broader ........ 34
33. Trichomes 0.8–0.9 μ broad ........ 34. *L. ochracea* (p. 301)
33. Trichomes 4 μ broad, sheath with calcium incrustation...... 35. *L. calcifera* (p. 301)
34. Trichomes up to 10 μ broad ........ 35
34. Trichomes broader ........ 37
35. Filaments 6–10 μ broad, cells 4.5–8 μ long ........ 36. *L. palmarum* (p. 301)
35. Filaments broader ........ 36
36. Cells quadrate or longer than broad, filaments 13.5–14.5 μ broad
37. *L. aureo-fulva* (p. 302)
36. Cells not longer than broad ........ 38
37. Filaments 10–11 (–12) μ broad, trichomes 9–10 μ broad, cells ½–1 as long as broad........ 38. *L. dendrobia* (p. 302)
37. Filaments 12–16 μ broad, trichomes 8–12 μ broad, cells ½–⅓ as long as broad
39. *L. corticicola* (p. 303)
38. Trichomes constricted, 16–12 μ broad, cells 5–6 (10) μ long
40. *L. arboricola* (p. 305)
38. Trichomes unconstricted ........ 39
39. Trichomes 8–24 μ broad, often with gas-vacuoles, septa granulated
41. *L. aestuarii* (p. 305)
39. Trichomes narrower, without gas-vacuoles septa not granulated ........ 40
40. Trichomes 12–17 μ broad, cells ⅙ as long as broad, cross-walls granulated
42. *L. connectens* (p. 308)
40. Trichomes 12–14 μ broad, cells very short, 3–4 μ long, cross-walls not granulated
43. *L. truncicola* (p. 308)
41. Filaments up to 4 (–5) μ broad ........ 42
41. Filaments broader ........ 49
42. Trichomes narrower than 1 μ ........ 44. *L. erebi* (p. 309)
42. Trichomes broader ........ 43
43. Trichomes 1–2 μ broad ........ 45. *L. perelegans* (p. 309)
43. Trichomes 2–3.2 μ broad ........ 44
44. End cells capitate ........ 46. *L. lutea* (p. 310)
44. End cells not capitate ........ 45
45. End cell conical pointed ........ 47. *L. scotti* (p. 310)
45. End cell rounded ........ 46
46. Cells quadratic ........ 47
46. Cells up to twice as long a broad ........
47. Trichomes 2–3 μ broad, unconstricted septa not granulated.... 48. *L. digueti* (p. 310)
47. Trichomes 2.5–4 μ broad, slightly constricted, septa granulated
49. *L. kuetzingiana* (p. 311)
48. Trichomes 2.8–3.2 μ broad, cells 2–6.4 μ long, unconstricted, septa not granulated
50. *L. versicolor* (p. 311)
48. Trichomes 2 μ broad, cells 1½–2 times as long as broad
51. *L. porphyrosiphonis* (p. 313)
48. Trichomes 3.5–4 μ broad, quadratic to 1½ as long as broad
52. *L. allorgei* (p. 313)

49. In salt water ........ 50

49. In freshwater ........ 52

50. Trichomes 16–60 (–80) μ broad, without calyptra .. 53. *L. majuscula* (p. 313)

50. Trichomes narrower ........ 51

51. Trichomes 9–25 μ broad, without calyptra ........ 54. *L. confervoides* (p. 314)

51. Trichomes 7–15 μ broad, without calyptra ........ 55. *L. cinerescens* (p. 315)

51. Trichomes 5–12 μ broad, with calyptra ........ 56. *L. semiplena* (p. 315)

52. Trichomes 3.5–6 μ broad ........ 53

52. Trichomes broader ........ 54

53. Cells quadratic or longer than broad ........ 52. *L. allorgei* (p. 313)

53. Cells quadratic or shorter than broad ........ 57. *L. aerugineo-coerulea* (p. 315)

54. Trichomes 6–12 μ broad ........ 55

54. Trichomes broader ........ 59

55. Cells 1–½–¼ as long as broad ........ 56

55. Cells very short ........ 58. *L. stagnina* (p. 317)

56. End cells with calyptra ........ 59. *L. nigra* (p. 317)

56. End cells without calyptra ........ 57

57. Trichomes constricted at the cross-walls ........ 60. *L. putealis* (p. 317)

57. Trichomes unconstricted ........ 58

58. Trichomes 6–10 μ broad, cells 1.7–3.3 μ long..... 61. *L. martensiana* (p. 318)

58. Trichomes 9–10 μ broad, cells 3.5–4 μ long......... 62. *L. corbierei* (p. 320)

59. Trichomes broader, 28–36 μ broad ........ 63. *L. magnifica* (p. 320)

59. Trichomes narrower ........ 60

60. Sheath thick, lamellated, trichomes 11–16 μ broad .... 64. *L. major* (p. 320)

60. Sheath thick, distinctly lamellated, trichomes 18–27 μ broad 65. *L. subconfervoides* (p. 321)

### 1. **Lyngbya chaetomorphae** Iyengar et Desikachary

A systematic account of some Marine Myxophyceae of the South Indian Coast, J. Madras Univ., sec. B., 16(1): 58, fig. 22, 1944.

Pl. 49, Fig. 3

Trichomes erect, light blue-green in colour, short, up to 26.2 μ long, usually about 1.3 μ broad; apex rounded, not calyptrate, not constricted at the cross-walls, cross-walls not granulated; sheath very thin and hyaline, closely investing the trichome, cells shorter than broad.

On *Chaetomorpha litorea* floating in masses in the aestuarine region of the River Cooum, Madras (Iyengar and Desikachary, *loc. cit.*).

### 2. **Lyngbya lachneri** (Zimmermann) Geitler

Kryptogamenflora, 1037, fig. 655, 1932.

= *Oscillatoria lachneri* Zimm., Zeitschr. Bot., 20: 18, pl. Id, IIe, 1928.

Filaments attached by one end, single nearly straight, apparently without a sheath, but with a hyaline sheath visible under high magnification, seldom longer than 100 μ; trichome 2.5–3.5 μ broad, constricted at the cross-walls, cells 1.5–3 μ long; end cell rounded, colour violet; hormogonia present.

Attached to rocks in a brooklet, Nettayam, Travancore (Parukutty, 1940, 123) — (filaments 4.2–6.6 μ broad; cells 1.6–2.5 μ long).

### 3. **Lyngbya mesotricha** Skuja

Zur Süsswasseralgenflora Burmas, 54, pl. 9, figs. 1–7, 1949.

Pl. 50, Figs. 1, 2

Filaments erect or more or less curved, fixed to the substratum by the basal portion; growing together caespitose and fasciculate, rarely solitary, 3–5 μ broad, up to 1 mm long; sheath thin to moderately broad, firm, colourless; trichomes 2.5–3 μ broad, ends not attenuated, not constricted at the cross-walls, cross-walls marked with one or two large granules on either side; cells 1–2 times longer than broad, 4–8 μ long, contents pale blue-green; homogeneous; apical cell rotund or rounded conical, no calyptra.

Epiphytic on many heleophilen epiphytic algae, Rangoon ( ! ) Burma (Skuja, *loc. cit.*).

### 4. **Lyngbya infixa** Frémy

C. R. Acad. Sci., Paris, 195: 1414, 1932; Cyano. cotes d'Eur, 110, pl. 30, fig. 1, 1934.

Filaments solitary or loosely united, suberect, flexuous, nearly elongate, attached by the base; sheath thin, conspicuous, hyaline, not coloured blue by chlor-zinc-iodide; trichome pale bluish, not constricted at the cross-walls, commonly 1.8–2 μ, rarely up to 2.8 μ broad; cells commonly shorter than long, rarely subquadrate, 1–2 μ long; septa conspicuous, pellucid, not granulated; contents with large granules; apical cells not attenuated, not capitate, outer wall not thickened.

Bandra, Bombay (Boergesen, 1935, p. 7); Galle, Ceylon (Boergesen, 1936, p. 60).

### 5. **Lyngbya kuetzingii** Schmidle

Algol. Notiz. IV, Allg. Bot. Zeitschr., 58, 1896; Forti in De Toni, Sylloge Algarum, 5: 280, 1907; Frémy, Myxo. d'Afr. équat. franc., 195, 1929; Geitler Kryptogamenflora, 1035, 1932.

Pl. 48, Fig. 2

Filaments straight or slightly curved or bent, rigid, single or many and gregarious, 2–3.5 μ broad, often short and only 30–70 μ long, with one end

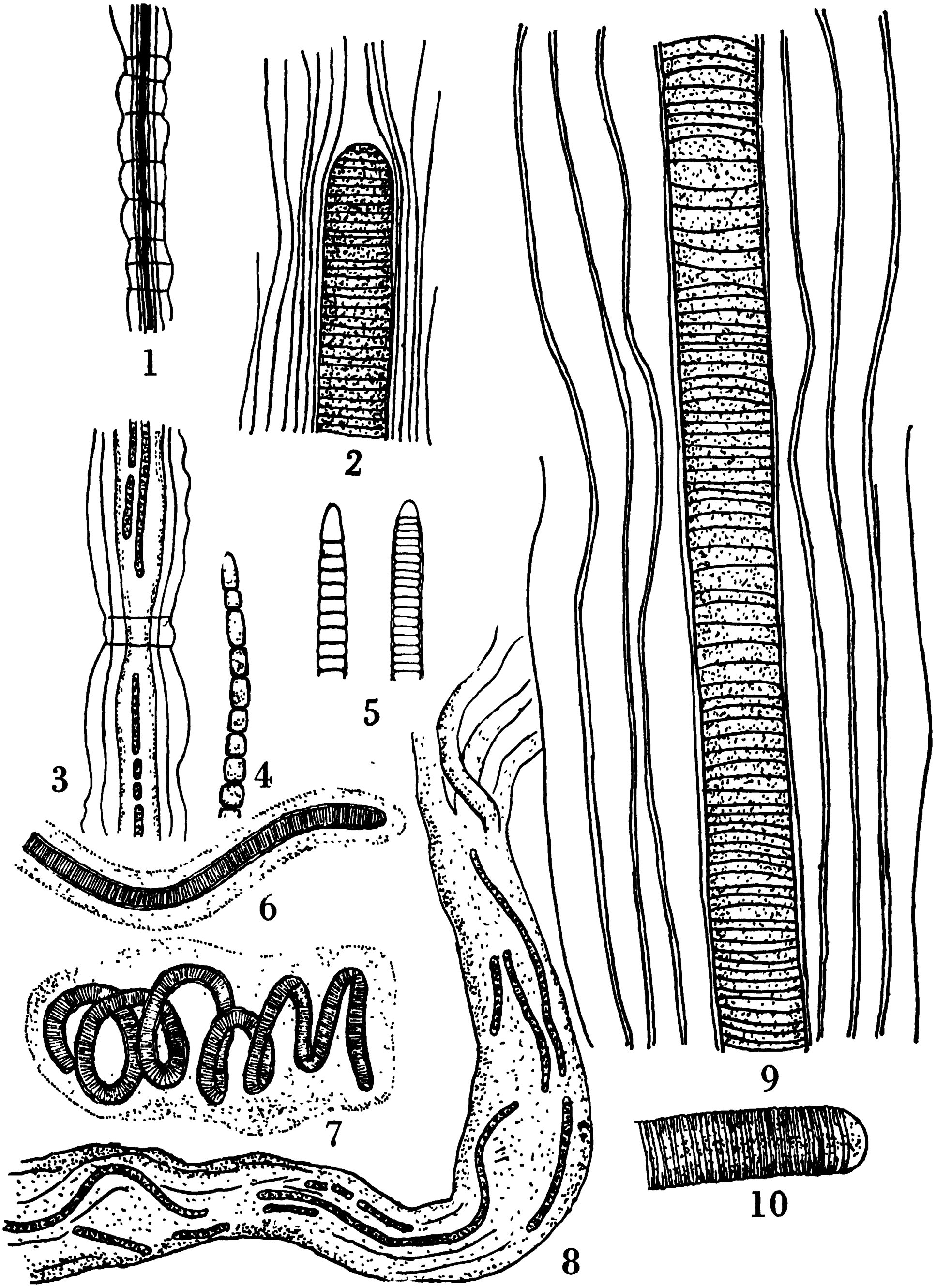

PLATE 47, Figs. 1–10.

1, 2. *Polychlamydum insigne* West, W. et G. S. (Orig.); 3, 4, 8. *Dasygloea amorpha* Berk. (3. after Gomont; 4, 8. after West & West); 5. *Sirocoleus kurzii* (Zeller) Gom. (after Gomont); 6, 10. *Katagnymene pelagica* Lemm. (after Karsten); 7. *K. spiralis* Lemm. (after Karsten); 9. *Porphyrosipnon notarisii* (Menegh.) Kütz. (Orig.).

fixed or attached; sheath thin colourless, coloured violet with chlor-zinc-iodide; cells 1.5–2 μ broad, 1/2–1/3 as long as broad, not constricted at the cross-walls and not granulated, pale blue-green.

On *Caldophora* and other filamentous algae in lakes and ponds. — Tank Mahakaduwewa and Mancadawawewa near Kerirawa, Ceylon (Crow, 1923b, 142); in a pond, Sherpur town in Bengal (Banerji, 1938, 105); and in the environs of Shembaganur (Frémy, 1942, 21).

Var. **minor** Gardner

Myxophyceae from Porto Rico, Mem. N. Y. Bot. Gard., 1: 39, pl. 8, fig. 76, 1927; Geitler Kryptogamenflora, 1035, fig. 654, 1932.

Filaments 50–80 μ long, 1.2–1.4 μ broad, straight, erect, stiff, sheath thin.

On *Lyngbya majuscula* in A. H. Gardens, Madras ( ! ).

6. **Lyngbya gardneri** (Setchell et Gardner) Geitler

Kryptogamenflora, 1037, 1932.

= *L. erecta* Setchell and Gardner, Proc. Calif. Acad. Sci., 4th ser., 122, 1930 *non L. erecta* Setchell and Gardner, 1927.

Pl. 49, Fig. 4

Filaments 1–2 mm long, attached by a basal cell, forming a thick or dense, straight or slightly bent, 2.6–3 μ broad; trichome 1.3–1.6 μ broad, slightly constricted at the cross-walls; sheath indistinct, colourless, smooth; cells quadrate or somewhat longer or shorter than broad; end cells rounded.

On *Lyngbya majuscula,* Dhanushkodi (Iyengar and Desikachary, 1944, 59).

The trichomes are 1.3–2 μ broad in the Dhanushkodi material.

7. **Lyngbya epiphytica** Hieron.

in Kirchner, Schizophyceae in Engler—Prantl, Die Natürlichen Pflanzenfam., I, la: 67, 1898; Lemmermann, Das Plankton Schwedischer gewasser, Ark. f. Bot., 2: 103, pl. 1, fig. 10, 1903–04; Forti in De Toni, Sylloge Algarum, 5: 289, 1907; Frémy, Myxo. d'Afr. équat. franc., 195, fig. 162, 1929; Geitler, Kryptogamenflora, 1038, fig. 656d, 1932. *non* Wille.

Pl. 53, Fig. 7

Filaments growing in a thick or loosely spiral manner on other algae, 1.5–2 μ broad; sheath thin, colourless; cells 1–1.5 μ broad, 1–2 μ long, not constricted at the cross-walls and not granulated; end cells hemispherical, not attenuated.

On *Microchaete uberrima, Lyngbya major,* and *Plectonema wollei* in pond in Mandalay (Skuja, 1949, 53).

### 8. **Lyngbya sordida** (Zanard.) Gomont

Monogr. Oscillariées, 126, pl. 2, fig. 21, 1892; Forti in De Toni, Sylloge Algarum, 5: 260, 1907; Geitler, Kryptogamenflora, 1039, fig. 657b, 1932; Frémy, Cyano. cotes d'Eur., 103, pl. 26, fig. 5, 1933.

Pl. 52, Fig. 1

Thallus caespitose, fasciculate, bushy, dull or dirty yellowish green, when dried dark violet, up to 3 cm high; filaments more or less straight; sheath smooth, coloured violet with chlor-zinc-iodide; trichome olive-green, when dried purple, blue or yellowish green, distinctly constricted at the cross-walls, ends not attenuated, 14–31 μ broad; cells $\frac{1}{3}-\frac{1}{6}$ as long as broad, 4–10 μ long; end cell rounded, with calyptra.

Galle, Ceylon (Boergesen, 1936, 6).

### 9. **Lyngbya baculum** Gomont

Essai class. Nost., J. Bot., 4: 354, 1890; Monogr. Oscillariées, 123, pl. 2, fig. 17, 1892; Forti in De Toni, Sylloge Algarum, 5: 259, 1907; Geitler, Kryptogamenflora, 1039, fig. 657c, 1932; Frémy, Cyano. cotes d'Eur., 101, pl. 26, fig. 1, 1933.

Pl. 49, Fig. 5 & Pl. 52, Fig. 3

Thallus caespitose, violet, up to 2 mm high, filaments more or less curved; sheath coloured violet with chlor-zinc-iodide; trichome blue-green or violet, constricted at the cross-walls, 8–11 μ broad, broadened at the apex; cells nearly quadrate to $\frac{1}{3}$ as long as broad, 3–7.5 μ long; end cells swollen, without calyptra.

On *Enhalus,* Pamban (Iyengar and Desikachary, 1944, 59).

Iyengar and Desikachary described a forma with filaments 13.1–14.4 μ broad. The Pamban alga agrees with the species in all respects but the trichomes are not constricted.

### 10. **Lyngbya gracilis** (Menegh.) Rabenh.

Fl. Eur. Alg., 2: 145, 1865; Gomont, Monogr. Oscillariées, 124, pl. 2, fig. 20, 1892; Forti in De Toni, Sylloge Algarum, 5: 259, 1907; Geitler, Kryptogamenflora, 1040, fig. 657a, 1932; Frémy, Cyano, cotes d'Eur., 102, pl. 26, fig. 3, 1933.

Pl. 52, Fig. 2

Thallus caespitose, extensive, dense floccose, lubricous, purplish violet, when dried often becoming colourless or dull yellow; sheath thin, smooth, not stained violet with chlor-zinc-iodide; trichome rose, constricted at the cross-walls, 5–8 μ broad, at the apex not attenuated; cells 1–½ times as long as broad, 2.8–4.6 μ long; end cell rounded, with slightly thickened outer wall.

Galle, Ceylon (Boergesen, 1935, 60); in the water of a storage tank, Benaras (Rao, C. B., 1937b, 371), on the submerged steps of a pond, Polamur (Rao, C. B., 1938a, 94) and in stagnant rainwater in an earthenware pot, Calcutta (Banerji, 1938, 105).

The diameter of the filaments in the Indian material varies from 8–11.8 μ.

### 11. **Lyngbya holdenii** Forti

In De Toni, Sylloge Algarum, 5: 260, 1907; Geitler, Kryptogamenflora, 1040, 1932.

Pl. 49, Fig. 6

Filaments attached to other algae by their middle with ends free, about 8 μ broad; sheath thin, delicate; trichome pale green, distinctly constricted at the cross-walls, 3–4.5 μ broad; cells subquadrate or up to 1/3 as long as broad (3–13 μ long); end cell rounded.

On other alga growing on chanks in deep-water at Rameshwaram (Iyengar and Desikachary, 1944, 59).

The Rameshwaram alga is reported to be rose-red in colour, probably because it was collected from deep waters. Iyengar and Desikachary describe the filament as 7–9 μ broad and the sheath up to 1 μ thick and trichome as 2.6–5.3 μ broad. Tilden describes the cells of algae as 3–13 μ in length.

### 12. **Lyngbya distincta** (Nordst.) Schmidle

Algol. Notizen, IV, Allg. Bot. Zeitschr., 58, 1896; Forti in De Toni, Sylloge Algarum, 5: 281, 1907; Geitler, Kryptogamenflora, 1041, 1932.

= *Leibleinia martensiana* var. *distincta* Nordst. Alg. aquae dulc. et. Charac. Sandwicensis, 4.

= *Lyngbya kützingii* var. *distincta* (Nordt.) Lemm. Algenfl. d. Sandwich Ins., Engler's Bot. Jahrb., 35: 620, 1906.

Filaments at first attached by one end, the other free, about 60 μ long, sometimes free, straight, or slightly curved, 1.8 μ broad, ends not attenuated; sheath very long, hyaline, not coloured violet by chlor-zinc-iodide; cells nearly as long as broad, blue-green.

Tank Andankulam near Trincomalie, Ceylon (Crow, 1923b, 142).

Crow describes the Ceylonese form as slightly capitate.

### 13. **Lyngbya polysiphoniae** Frémy

Myxo. d'Afr. équat. franc., 194, fig. 161, 1929; Geitler, Kryptogamenflora, 1040, fig. 656b, c, 1932.

Pl. 53, Figs. 4, 5

Filaments straight or curved, single or in bundle, epiphytic, up to 200 μ long; sheath very thin, delicate, papyraceous, colourless, not coloured violet with chlor-zinc-iodide; trichome pale blue-green or violet, constricted at the cross-walls, about 2 μ broad, apices not attenuated; cells 1/2–1/3 as long as broad, cross-walls visible, not granulated; end cells convex, not capitate.

In a tank, Paroor, Travancore (Parukutty, 1940, 123).

Parukutty gives the breadth of the filament as 3–3.3 μ and the length of the cells 0.8–1.0 μ.

Geitler (1932, p. 1041) queries if this species is not identical with *L. nordgardhii* Wille De Toni (Diag. Alg. nov. Myxo., Cent. VI, 580, 1939) transfers it to *L. nordgardhii.* There does not appear to be any difference except in the length of the normal cells.

Singh, V. P. (1941, 253) describes a form of this species growing on rocks on the banks of the River Ravi, Punjab. This alga (filament up to 2.2 μ broad, cells 0.73–1.1 μ long) differs in the much longer filaments and its habit.

### 14. **Lyngbya nordgardhii** Wille

Algol. Notizen, XXVIII, Nyt. Mag. Naturw. 56: 32, 1917; Geitler, Kryptogamenflora, 1041, fig. 658, 1932.

= *L. epiphytica* Wille, Nyt. Mag. Naturw., 51: 25, pl. 1, fig. 14–17, 1913. *non* Hieron.

= *L. willei* Setchell and Gardner, in Gardner New Pacific Coast Alg., 3, Univ. Calif. Publ. Bot., 3: 468, 1918; Frémy, Cyano, cotes d'Eur., 111, pl. 29, fig. 5, 1933.

Pl. 54, Figs. 1–3

Thallus small, caespitose, grey violet or grey brown; filaments very long, straight, or more or less bent or curved (3–4 μ broad) attached to other filamentous algae; sheath thin, delicate, smooth, not coloured blue by chlor-zinc-iodide; trichome grey violet, constricted at the cross-walls, 1.5–2 μ broad, not attenuated, cells 1–1/2 as long as broad, (up to 4 μ long); end cell rounded, without a thickened outer wall.

Epiphytic on *Lyngbya majuscula* var. *chakiense* in a pond, Namdur in Andhra (Rao, C. B., 1938a, 94); washed ashore near Dhanushkodi, in Madras State (Iyengar and Desikachary, 1944, 60).

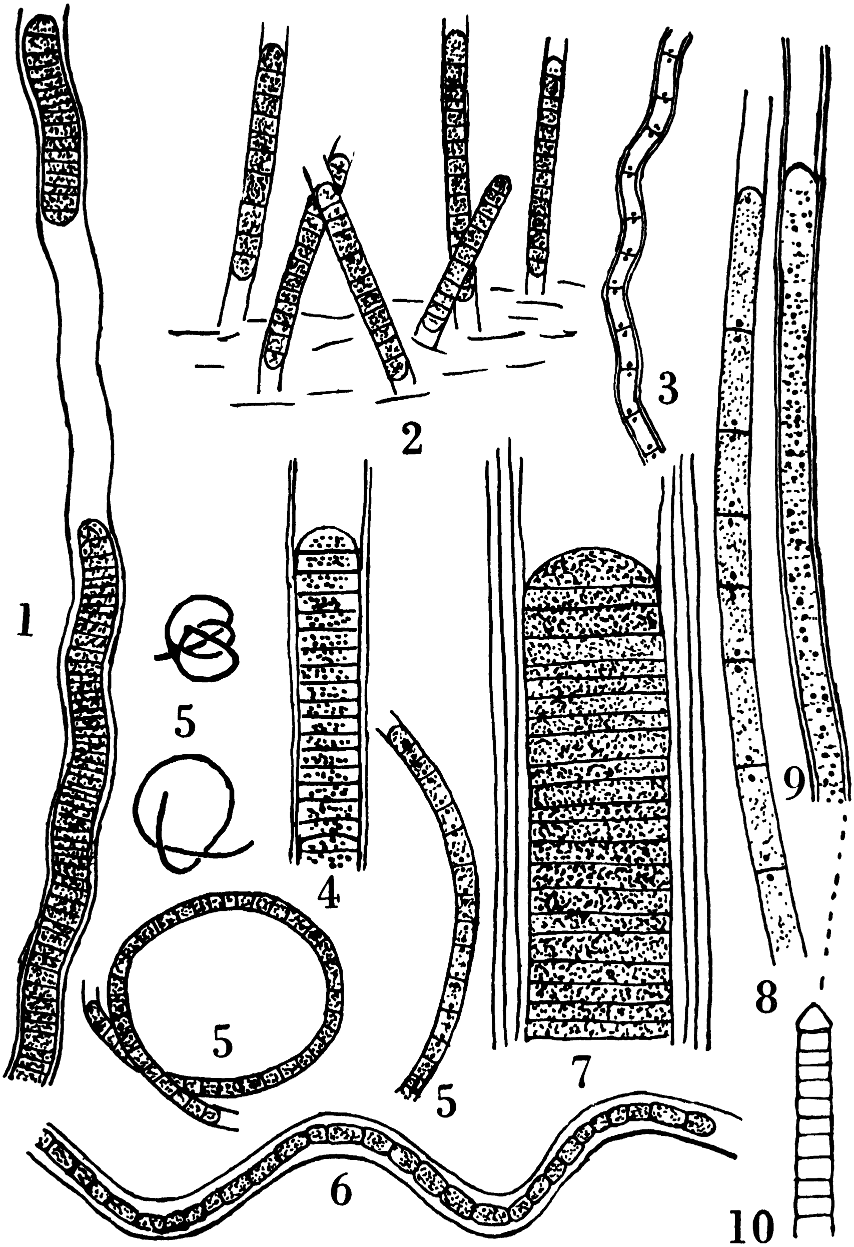

PLATE 48, Figs. 1–10.

1. *Lyngbya spiralis* Geitler (Orig.); 2. *Lyngbya kuetzingii* Schmidle (Orig.); 3. *L. bipunctata* Lemm. (after Lemm.); 4. *L. hieronymusii* Lemm. (after Lemm.); 5. *L. contorta* Lemm. (Orig.); 6. *L. lagerheimii* (Moebius) Gom. (Orig.); 7. *L. majuscula* Harv. (Orig.); 8. *L. perelegans* Lemm. (Orig.); 9, 10. *L. aeugineo-coerulea* (Kütz.) Gom. (after Gomont).

The trichome in the Namdur alga is not so prominently constricted as in the type. Iyengar and Desikachary (1944, 60) wrongly state that the apices are attenuated (cf. their fig. 26).

### 15. **Lyngbya spiralis** Geitler

Kryptogamenflora, 1042, fig. 659, 1932.

Pl. 48, Fig. 1

Filaments forming a thin leathery thallus blue-green or bluish black, 5–6 μ broad, entirely or for major part or at the ends spirally coiled; sheath not coloured violet by chlor-zinc-iodide, smooth, firm, not lamellated, colourless; trichome in living and in dried condition, pale blue-green not attenuated, not capitate, 4.5–5 μ broad, cells mostly 1/3 seldom up to 1/2 as long as broad, 1.5–2.5 μ long; end cell broadly rounded, without a thickened outer wall, calyptra absent.

Along with other gelatinous algae in a cement tub, in laboratory, Madras (!).

In the Madras algae the filaments are broader (6.6–7.9 μ) and the trichomes (5.2–6.6 μ) are much broader than in the type.

### 16. **Lyngbya laxespiralis** Skuja

Zur Süsswasseralgenflora Burmas, p. 53, pl. 10, figs. 10–11, 1949.

Pl. 50, Fig. 4

Filaments intermixed with algae commonly coiled into loose spirals, also sometimes irregularly bent or more or less straight, 9.5–11 μ broad, spirals when present 18–20 μ broad, distance between two spirals 100–110 μ; sheath thin, firm, colourless, not lamellated; trichomes 8.5–10 μ broad, not distinctly constricted at the cross-walls, cross-walls not granulated; cells generally shorter than broad; rarely quadrate, 5–8 μ long, contents pale blue-green to blue-green, homogeneous; apical cell rotund.

In a pool, Mandalay (Skuja, *loc. cit.*).

### 17. **Lyngbya spirulinoides** Gomont

J. de Bot., 4: 355, 1890; Monogr. Oscillariées, 146, pl. 3, figs. 18–19, 1892; Forti in De Toni, Sylloge Algarum, 5: 287, 1907; Geitler, Kryptogamenflora, 1041, fig. 658d, 1932.

Pl. 52, Figs. 4, 5

Thallus free-floating, olive green; filaments entangled, regularly and loosely spirally coiled, either throughout its length or partially, often straight, distance between two spirals 73–108 μ; sheath thin, colourless, lamellated, somewhat mucilaginous, not coloured violet by chlor-zinc-iodide; trichome not constricted at the cross-walls, 14–16 μ broad, pale blue-green; cells 1/2–1/5 as long as broad, 3.4–6.8 μ long, cross-walls sometimes granulated; end cell rounded and calyptra absent.

Along with *Schizothrix* forming aegagrophilous balls in a tank at Chingleput (Desikachary and Ramakrishnan ( ! ) ).

### 18. **Lyngbya bipunctata** Lemm.

Phytoplanct. Sachs Teiche, Plöner Forschber. 7: 133, pl. 2, fig. 48, 1899; Frémy, Myxo. d'Afr. équat. franc., 202, 1929; Geitler, Kryptogamenflora, 1043, 1932.

Pl. 48, Fig. 3

Filaments regulary but very loosely spirally coiled, 1.5–2 μ broad, single, free-floating; sheath narrow, colourless; cells 1–1.5 μ broad, 3.5–5.5 μ long, not constricted at the cross-walls, with a single refractive granule on either side of the cross-walls, pale blue-green; end cell rounded, not attenuated.

In the environs of Shembaganur, Madras State (Frémy, 1942, 21); Kokine lakes, Rangoon (Skuja, 1949, 52).

### 19. **Lyngbya contorta** Lemm.

Phytoplanct. Sachs Teiche in Plöner Forschber., 6: 202, pl. 5, figs. 10–13, 1898; Forti in De Toni, Sylloge Algarum, 5: 288, 1907; Frémy, Myxo. d'Afr. équat. franc., 202, fig. 172, 1929; Geitler, Kryptogamenflora, 1043, fig. 660a, b, 1932; Frémy, Cyano. cotes d'Eur., 109, pl. 29, fig. 2, 1933.

Pl. 48, Fig. 5 & Pl. 50, Figs. 5, 9

Filaments single, free-floating, regularly spirally coiled, with a delicate, nearly circular coils, 1–1.5 μ broad; sheath narrow, colourless; cells 1–2 μ broad, 3–5 μ long, not constricted at the cross-walls, granulated with a single granule or without them; end cell rounded, not attenuated.

Plankton in Colombo lake (Lemmermann, 1907, 267), Lake Cantelai (Crow, 1923b) and Mont lake near Colombo in Ceylon (Skvortzow, 1928, 109); Rangoon (Skuja,· 1949, 52); in a tank, Sholinghur, Chingleput District, Madras State ( ! ).

### 20. **Lyngbya lagerheimii** (Möb.) Gomont

Essai class. Homo., J. de. Bot., 4: 354, 1890; Monogr. Oscillariées, 147, pl. 4, figs. 6, 7, 1892; Frémy, Myxo. d'Afr. équat. franc., 201, fig. 170, 1929; Geitler, Kryptogamenflora, 1044, fig. 661g, 1932.

Pl. 48, Fig. 6 & Pl. 53, Fig. 2

Filaments single, or entangled with one another, irregularly spirally coiled or occasionally straight; sheath thin, colourless; trichome about 2 μ broad; cells 1.2–3 μ long not constricted at the cross-walls, with or without a single granule on either side, pale blue-green; end cell rounded, not attenuated.

Free-floating in a tank, Delhi (Rao, C. S., 1940, 131).

### forma **minor** nom. nov.

= forma Skuja, Zur Süsswasseralgenflora Burmas, 53, 1949.

Filaments between various other filamentous algae, irregularly bent or spirally coiled, 2.5–2.7 μ broad; sheath thin, colourless; trichome not constricted or very little constricted at the cross-walls, about 1.2–1.5 μ broad, cross-walls distinct, thick, not granulated; cells 1 1/2–2 times as long as broad.

Epiphytic and in a pond, Mandalay (Skuja, *loc. cit.*); in a laboratory culture of Red Hills lake ( ! ) and in a small pool, at Ennore near Madras ( ! ).

The filaments in the Madras algae were 2.6–3 μ broad, the trichome 1.3–2 μ broad, and the cells up to 3.9 μ long.

Probably Rao's specimens (*loc. cit.*) also belong here.

### 21. **Lyngbya circumcreta** West, G. S.

J. Linn. Soc., Bot., 38: 174, pl. 9, fig. 7, 1907; Frémy, Myxo. d'Afr. équat. franc., 202, fig. 171, 1929; Geitler, Kryptogamenflora, 1044, 661k, 1932.

Filaments single, free-floating, short, spirally coiled, spirals broad, very narrow, with 2–9 mostly 2–2 1/2 turns; sheath very thin, firm, colourless; cells nearly quadrate or somewhat shorter than broad, 1.8–2.1 μ broad, 1–2 μ long, not constricted at the cross-walls, cross-walls not granulated, pale blue-green; end cell rounded, with calyptra.

Planktonic in Nuwara Wewa tank in Ceylon (Holsinger, 1954, 9).

Geitler (1932, 1043) feels that species may be identical with *L. distincta.*

Ostenfeld (Phytopl. Victoria Nyanza, 1908, 335) includes it in *Lyngbya lagerheimii* Gomont.

### Var. **gelatinicola** Ghose

J. Linn. Soc. Bot., 46: 340, pl. 31, fig. 7, 1924.

Pl. 51, Fig. 8

Thallus dull blue-green, attached; filaments spirally coiled up to 20 or more spirals, spirals 100 μ broad; sheath thin, trichome about 1 μ broad; cells mostly shorter than broad, subquadrate, cross-walls commonly distinct; end cell rotund truncated.

Forming a gelatinous stratum on the walls of a drain, Lahore (Ghose, *loc. cit.*).

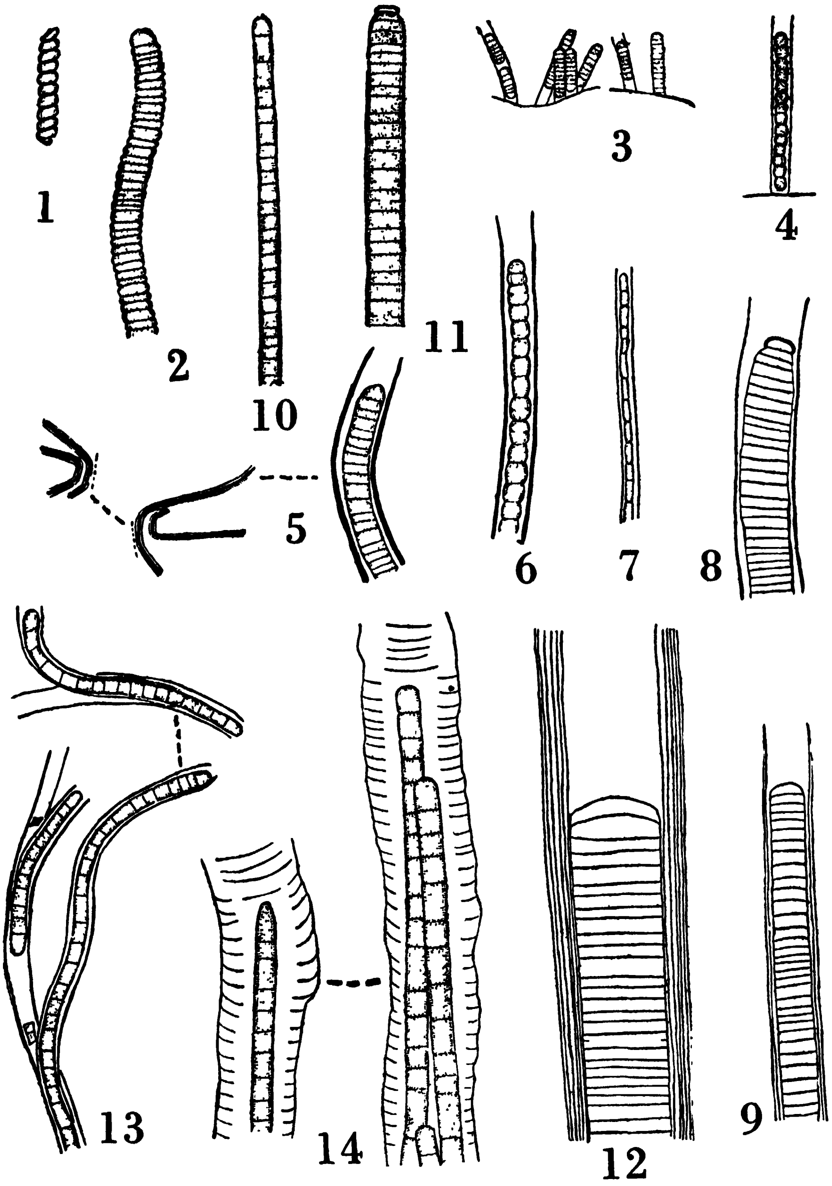

PLATE 49, Figs. 1–14.

1. *Spirulina labyrinthiformis* (Menegh.) Gom. (after Iyengar & Desikachary); 2. *Oscillatoria nigroviridis* Thwaites (after Iyengar & Desikachary); 3. *Lyngbya chaetomorphae* Iyengar et Desikachary (after Iyengar & Desikachary); 4. *L. gardneri* (Setchell & Gardner) Geitler (after Iyengar & Desikachary); 5. *L. baculum* Gom. (after Iyengar & Desikachary); 6. *L. holdenii* Forti (after Iyengar & Desikachary); 7. *L. nordgardhii* Wille (after Iyengar & Desikachary); 8. *L. semiplena* Ag. (after Iyengar & Desikachary); 9. *L. confervoides* Ag. (after Iyengar & Desikachary); 10. *Oscillatoria subuliformis* Kütz. (after Iyengar & Desikachary); 11. *Trichodesmium erythraeum* Ehrenb. (after Iyengar & Desikachary); 12. *Lyngbya majuscula* Harv. (after Iyengar & Desikachary); 13. *Symploca hydnoides* f. *minor* Iyengar et Desikachary (after Iyengar & Desikachary); 14. *Microcoleus chthonoplastes* (after Iyengar & Desikachary).

Geitler, feels that this belongs to another species with only occasional formation of spirals.

### 22. **Lyngbya rivularianum** Gom.

Monogr. Oscillariées, 148, 1892; Forti in De Toni, Sylloge Algarum, 5: 282, 1907; Frémy, Myxo. d'Afr. équat. franc., 201, 1929; Geitler, Kryptogamenflora, 1048, 1932; Frémy, Cyano. cotes d'Eur., 112, pl. 29, fig. 6, 1933.

Filaments single in the mucilage of other algae, coiled; sheath thin, colourless, papery; trichomes 0.75–0.8 μ broad, not constricted at the cross-walls, cross-walls not granulated, ends not attenuated pale blue-green; cells up to 4 times as long as broad, 2.3–3.2 μ long; end cell rotund; calyptra none.

In the mucilage of *Gloeocapsa montana, Nostoc, Nostochopsis lobatus* and among *Symploca.*—On dripping rocks at Therria, Assam (Biswas, 1934, 11); in Kyauktan, Tanuggyi canal and Rangoon, Burma (Skuja, 1949, 55).

Biswas (1942, 198) reports this alga occurring as a plankton in the River Hooghly. Skuja records a much broader form from Lettland. The Assam alga appears to be also much bigger than the type (trichome 0.8–1.5 μ broad; cells about 1–2 μ long).

### 23. **Lyngbya mucicola** Lemmermann

Plankt. Schwed. Gewäss., Ark. f. Bot., 2: 70, 1904; Kryptogamenflora der Mark Brandenburg, 3: 137, 1910; Forti in De Toni, Sylloge Algarum, 5: 289, 1907; Frémy, Myxo. d'Afr. équat. franc., 200, fig. 168, 1929; Geitler, Kryptogamenflora, 1049, fig. 661c, 1932.

= *L. gloiophila* Lemm., Ergebn. einer Reise n.d. Pacific, Abh. nat. Ver. Brem., 16: 355, pl. 2, fig. 36, 1899, *non* Hansgirg.

Filaments single in the mucilaginous thalli of other algae, variously bent, 1.5 μ broad, sheath delicate, hyaline; trichome 0.5 μ broad, not constricted at the cross-walls, cross-walls marked by a strongly refractive granule on either side; cells 1.5 μ long, pale blue-green; ends not attenuated, end cell rotund.

In the environs of Shembaganur, Madras State (Frémy, 1942, 21); in the mucilage of other algae, Kemmandine and in a running soiled trench water, near Rangoon, Burma (Skuja, 1949, 55).

### 24. **Lyngbya borgerti** Lemmermann

A small list of Ceylon algae, Zool. Jahrb., Abt. f. Syst., 25: 264/265, fig. a, 1907; Geitler, Kryptogamenflora, 1047, fig. 662a, 1932.

Pl. 53, Fig. 12

Filaments single, free-floating, mostly coiled, seldom very straight, 2.6–3 μ broad, cells 2–2.5 μ broad, 2.6–5 μ long, not constricted at the cross-walls, with an irregularly placed gas-vacuole in the middle of the contents, with highly refractive granules, end cell rounded.

Planktonic in Gregory lake, Ceylon (Lemmermann); in a paddy field, Attingal, Travancore (Parukutty, 1940, 123).

Parukutty's alga differs from the type. The filament and trichome are much broader (filaments 4.5–6 μ broad, trichomes 4.1–4.9 μ) and the cells are very short (1–1.6 μ).

### 25. **Lyngbya limnetica** Lemmermann

Beitrage z. Kenntnis d. Plankt. Alg., II, Bot. Centralbl., 76: 154, 1898; Kryptogamenflora der Mark Brandenburg, 3: 102, fig. 8, 1910; Forti in De Toni, Sylloge Algarum, 5: 286, 1907; Frémy, Myxo. d'Afr. équat. franc., 198, fig. 165, 1929; Geitler, Kryptogamenflora, 1046, figs. 661a, b, 1932; Frémy, Cyano. cotes d'Eur., 110, pl. 29, fig. 3, 1933.

Pl. 50, Fig. 11

Filaments straight or slightly curved or coiled, single, free-floating, 1–2 μ broad; sheath thin or narrow, colourless, not coloured blue by chlor-zinc-iodide; cells 1–1.5 μ broad, quadrate to 1/3 rarely 1/8 as long as broad, 1–3 μ long, not constricted at the cross-walls, with or without a granule at the cross-walls, pale blue-green; end cells not attenuated, rounded.

In an ornamental reservoir, Benaras (Rao, C. B., 1937b, 372); in cultures of soils from Mirzapur, Benaras and Basti (Singh, R. N., 1939a, 61); in the environs of Shembaganur (Frémy, 1942, 21); in lakes and ponds, Rangoon and Mandalay in Burma (Skuja, 1949, 53).

This species has also been reported from Ceylon (Beira lake, Nuwara-wewa tank and Gregory lake) by Holsinger (1954, p. 17, fig. 4D).—Filaments free-floating, solitary, straight or slightly curved; trichomes 0.7–1.0 μ broad, not constricted at the septa, not tapering at the ends, end cell rounded, not capitate; sheath firm, very thin, colourless; cells cylindrical, 2–3.5 μ long.

### 26. **Lyngbya subtilis** West, W.

Algae of English lakes distr., J. Roy. micr. Soc., 1892: 741, pl. 10, fig. 5, 1892; *non* Holden, *non* Hansgirg. Forti in De Toni, Sylloge Algarum, 5: 285, 1907; Geitler, Kryptogamenflora, 1046, 1932.

Filaments solitary, free-floating, flexuous; trichome 1.5–1.8 μ diam., pale blue-green; sheath close, colourless; cells up to 2 times longer than broad; cell contents homogeneous, pale blue-green.

Along with *Tolypothrix byssoidea* on the barks of *Terminalia catappa,* Calcutta (Bruhl and Biswas, 1923, 10).

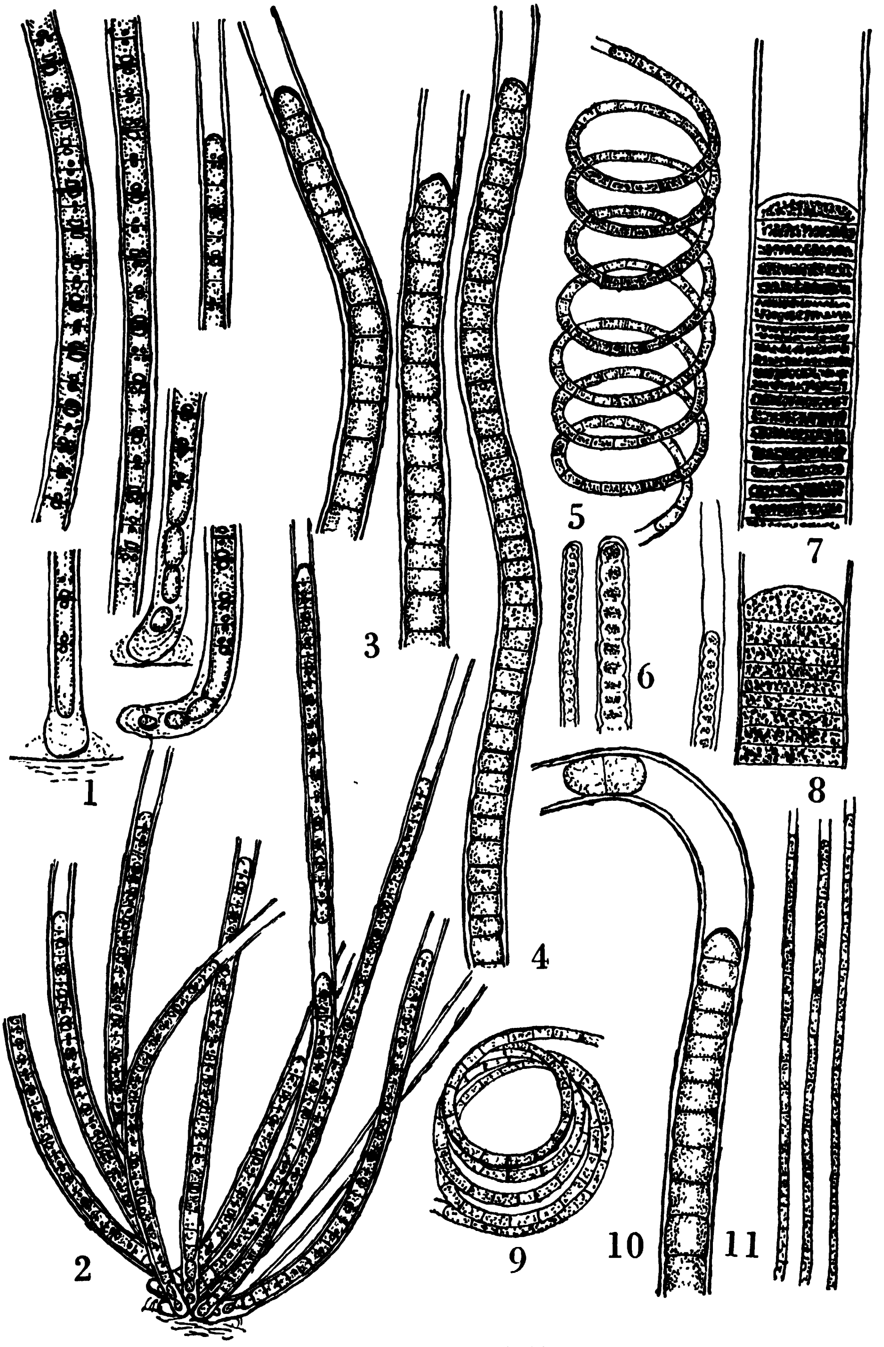

PLATE 50, Figs. 1–11.

1, 2. *Lyngbya mesotricha* Skuja (after Skuja); 3, 10. *L. dendrobia* Bruhl et Biswas (after Skuja); 4. *L. laxespiralis* Skuja (after Skuja); 5, 9. *L. contorta* Lemm. (after Smith); 6. *L. cryptovaginata* Schkorbatow (after Schkorbatow); 7, 8. *L. birgei* Smith, G. M. (after Smith); 11. *L. limnetica* Lemm. (after Smith).

Bruhl and Biswas (1923, p. 11, pl. 1, figs. 7a, b) describe a var. *granulosa* B. and B. which differs from the type in having granular contents. The filaments in this alga are 2–3 μ diam. This species has not been recorded earlier from subaerial situations. West describes the sheath as thin and closely attached to the trichome. Bruhl and Biswas in their var. *typica* give the sheath as less than 0.5 μ thick.

### 27. **Lyngbya birgei** Smith, G. M.

New or interesting Algae from the Lakes of Wisconsin, Bull. Torrey bot. 61; 43: 482, pl. 26, fig. 28, 1916; Geitler, Kryptogamenflora, 1048, fig. 663, 1932.

Pl. 50, Figs. 7, 8

Filaments straight, seldom coiled, free-floating, 20–24 μ broad; sheath firm, colourless, mostly unlamellated, seldom lamellated, 0.5–4 μ thick; trichome not constricted at the cross-walls, 18–23 μ broad, ends rounded, not attenuated, not capitate; cells shorter than broad, 2–2.5 μ long, sometimes with gas-vacuoles.

In paddy-fields, Parukada and on the wet mud of a drying tank, Alleppey, Travancore (Parukutty, 1940, 123); in a tank at Bandra near Bombay (Gonzalves and Joshi, 1946, 168).

The Travancore alga is slightly broader (filaments 23.1–26.4 μ broad, trichome 22–24 μ broad, cells 3–3.9 μ long).

Gupta (1956) reports a form.—

Filaments 30–34 μ broad, trichomes 26–28 μ broad, distinctly constricted at the cross-walls; cells 5–7 μ long.

Free-floating in filter beds in Khusroobag, Allahabad (Gupta, *loc. cit.*).

### 28. **Lyngbya shackletoni** W. et G. S. West

Brit. Antarctic Exped., 1, 1911; Geitler, Kryptogamenflora, 1047, fig. 662c, 1932.

Pl. 53, Fig. 13

Filaments nearly straight, 12–12.5 μ broad; sheath firm, colourless, distinctly lamellated; trichome not attenuated at the ends, 8.5–9.5 μ broad, not constricted at the cross-walls; cells 2–2.4 μ long, pale blue-green; end cell conical nearly as long as broad.

In a pool Veli, Travancore (Parukutty, 1940, 123).

The Travancore alga differs from the type in the filaments (13–15 μ) and the trichomes (9–10 μ) being broader. The cells in this alga are 1.6–3 μ long.

### 29. **Lyngbya hieronymusii** Lemm.

Forschbers., Plön, 12: 146, pl. 4, figs. 12, 13, 1905; Kryptogamenflora der Mark Brandenburg, 3: 139, fig. 6 (on p. 102), 1910; Frémy, Myxo. d'Afr. équat. franc., 192, fig. 160, 1929; Geitler, Kryptogamenflora, 1047, fig. 656a, 1932.

Pl. 48, Fig. 4

Filaments single, free-floating, straight or slightly bent, 12–14 μ broad; sheath firm, homogeneous, colourless, not coloured violet by chlor-zinc-iodide; cells 11–13 μ broad, 2.5–4 μ long, not constricted at the cross-walls, granulated, with gas-vacuoles not attenuated; end cell broadly rounded.

Rice fields and ponds, Allahabad (Mitra, A. K., 1951, 359; Gupta, 1956, 79).

Mitra's var. *major* is a *nomen nudum.*

#### f. **robusta** Parukutty

The Myxophyceae of Travancore State, Proc. Indian Acad. Sci., b, 11: 123, 1940.

Filaments 26.4–33 μ broad; sheath broader; trichome 15–17 μ; cells 3–3.5 μ long.

In a stagnant pools, Chabara, Travancore (Parukutty, *loc. cit.*).

#### Var. **crassivaginata** Ghose

The Myxophyceae of Rangoon III, J. Burma Res. Soc., 17: 240, pl. 2, fig. 8, 1927b.

Pl. 55, Fig. 8

Filaments single, free-swimming, or a little curved, 15–20 μ broad; sheath thick, hyaline; cells 11–14 μ broad, up to 10 μ long, not constricted at the joints, but granulated at the dissepiments, with pseudovacuoles; apical cell not attenuated, broadly rounded.

Free-swimming near the banks, Victoria lakes, Rangoon, Burma (Ghose, *loc. cit.*).

### 30. **Lyngbya cryptovaginata** Schkorbatow

Beobachtung über einige Cyanophy. d. Gouvern Charkov (Ukraine) Arch. Russ. Protistologia, 6 (–4): 125, pl. 8, figs. 14–16, 1927; Geitler, in Pascher's Süsswasserflora, 12: 401, 1925.

Pl. 50, Fig. 6

Filaments single, free-floating, straight, 4–9 μ broad; sheath colourless, delicate, at first often not distinctly visible but later (in cultures) distinct, not coloured blue by chlor-zinc-iodide; trichome slightly constricted at the cross-walls, blue-green; cells nearly quadrate, or up to 1/2 as long as broad, with pseudovacuoles; end cells rounded.

In rain water puddles inside Jogeshwari caves near Bombay (Gonzalves and Joshi, 1943b, 121, pl. 2, fig. 7).

### 31. **Lyngbya kashyapii** Ghose

A systematic and ecological account of a collection of blue-green algae from Lahore and Simla. J. Linn. Soc. Bot., 46: 339, pl. 31, fig. 5, 1924; Geitler, Kryptogamenflora, 1055, 1932.

Pl. 51, Fig. 3

Thallus expanded, dull purple; filaments curved, densely intricate; sheath firm, thick, dull blue or purple, smooth, ' chitinous '; trichome 3–4 μ broad, not constricted at the cross-walls; cells quadrate or shorter than broad, cross-walls not granulated, often oblique or curved; end cells rotund, not capitate, calyptra none.

On moist grounds such as in the drying tanks, Shalimar gardens, Lahore (Ghose, *loc. cit.*).

Geitler suggests a redescription of the species. The chitinous nature of the sheath and the nature of the cross-wall need confirmation.

### 32. **Lyngbya rubida** Frémy

Myxo. d'Afr. équat. franc., 187, fig. 155, 1929; Geitler, Kryptogamenflora, 1054, fig. 668c, 1932.

Pl. 53, Fig. 10

Thallus floccose or caespitose, more or less expanded, brownish purple; filaments straight, stiff, up to 3 cm long, 6–7 μ seldom up to 8 μ broad, loosely intricate; sheath about 1 μ broad, firm, unlamellated, at first colourless, later reddish, not coloured violet with chlor-zinc-iodide; trichome gray blue-green, not constricted at the cross-walls, 4–4.5 μ broad, at the ends not attenuate, not capitate; cells 1 1/2–3 times as long as broad, 7.5–12 μ long, cross-walls not granulated; end cells rotund, calyptra absent.

In partially reclaimed Usar soils, Allahabad and in rice and wheat field soils, Allahabad (Mitra, A. K., 1951, 359/362).

Rao, C. B. (1937b, 373 and 1938b, 169) records two forms of this one from Benaras and the other from Berhampur. The forms are characterized by broader filaments and trichomes and a hyaline sheath.

Rao, (Myxophyceae of United Province, Proc. Indian Acad. Sci., B, 6: 373, 1937b,) describes a form.

Filaments 6–8 μ broad; sheath hyaline; trichome 4.8–5 μ broad, cells 4–8 μ long.

In a stagnant pond, Benaras.

Rao, (The Myxophyceae of Orissa Province, Proc. Indian Acad. Sci., B, 8: 169, 1938b,) describes another form.

Filaments 7.5–8.5 μ broad; sheath hyaline, up to 1 μ thick; trichome 5.5–6.6 μ thick; cells 5–9 μ long.

In a stagnant pond, Berhampur.

A. K. Mitra (1951, p. 359) reports a forma but he does not describe the same and is a *nomen nudum*.

### 33. **Lyngbya ceylanica** Wille

Denkschr. Akad. Wiss. Wien. Math. nat. Kl., 91: 161, pl. 3, figs. 27–29, 1914; Frémy. Myxo. d'Afr. équat. franc., 184, fig. 153, 1929; Geitler, Kryptogamenflora, 1054, fig. 668a, 1932.

incl: var. *constricta* Frémy, Myxo. d'Afr. équat. franc., 184, fig. 153, 1929.

Pl. 54, Fig. 4

Thallus olive-green, violet or red; filaments 10–14 μ broad, straight; sheath thin, colourless, when older often red, not coloured violet by chlor-zinc-iodide; trichome blue-green or violet, unconstricted at the cross-walls, not attenuated at the ends, 8–12 μ broad, cross-walls not granulated; cells quadrate to 1/2 or 1/3 as long as broad; end cell rotund, without calyptra.

On moist soil, Ceylon (Wille *loc. cit.*); on the barks of *Hevea brasiliensis*, Kamaw, Kaisseraing islands, Burma (Ghose, 1927c, 249); on moist in Cherrapunji plateau forming surface layer of algal bed, Assam (Biswas, 1934, 12), and on moist soil, Benaras (Rao, C. B., 1937b, 373).

Rao, C. B. (1937b, 373) described a *Lyngbya ceylanica* from Benaras, which differs very much in its dimensions — Filaments 12.8–19 μ broad; sheath 3.2–4 μ thick; trichome 9.6–11.2 μ broad; cells 4.8–6.4 μ long. In the absence of material it is difficult to say whether the Benaras alga belongs here at all. Two other forms are described by Rao, C. B. (1936, 14; 1938a, 94) from Benaras in U.P. and Namdur in Andhra State and these do not differ appreciably from the type.

Frémy (1929) describes a var. *constricta* (Pl. 54, Fig. 5). Geitler considered that in the species the constricted condition of the trichome varies in the same filament and as such is not of any importance in distinguishing the variety. Parukutty (1940, 125) reports from a stagnant pool in Veli in Travancore this variety (Filaments 27–30 μ broad, trichomes 19–23 μ broad, cells 6.6–10 μ long). The material needs a reinvestigation.

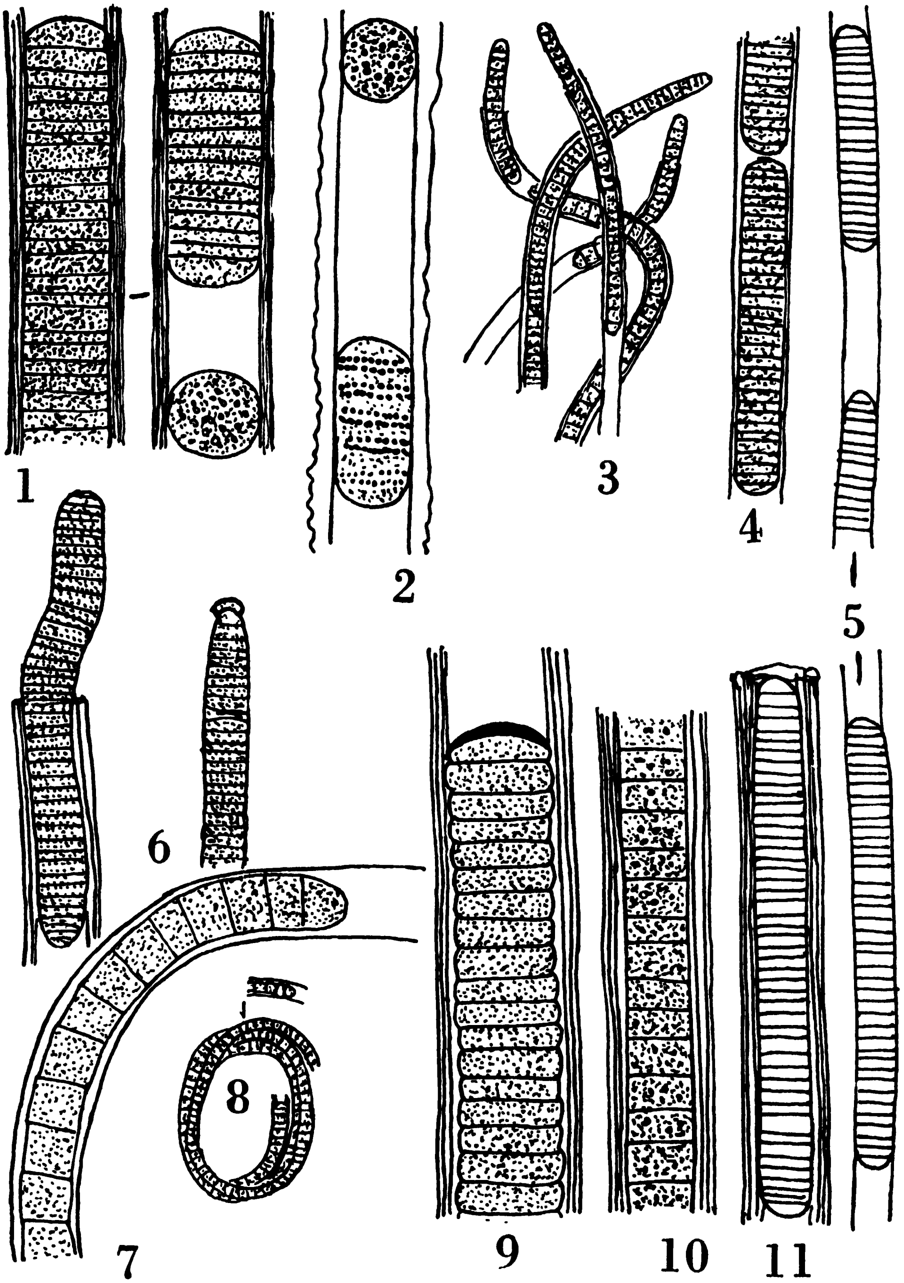

PLATE 51, Figs. 1–11.

1. *L. majuscula* var. *chakiaensis* Rao (after Rao, C. B.); 2. *L. martensiana* forma (after Bharadwaja); 3. *L. kashyapii* Ghose (after Ghose); 4. *L. truncicola* Ghose (after Ghose); 5, 6, 11. *L. connectens* Bruhl et Biswas (after Bruhl & Biswas); 7. *L. truncicola* var. *burmense* Ghose (after Ghose); 8. *L. circumcreta* var. *gelatinicola* Ghose (after Ghose); 9. *L. aestuarii* var. *constricta* Ghose (after Ghose); 10. *L. aestuarii* var. *arbustiva* Bruhl et Biswas (after Bruhl & Biswas).

34. **Lyngbya ochracea** (Kütz.) Thuret ex Gomont

Thuret, Essai class. Nostochinées, Ann. Sci. nat. Bot., 6th ser., 1: 279, 1875; Gomont, Mono. Oscillariées, 149, 1892; Forti in De Toni, Sylloge Algarum, 5: 283, 1907; Frémy, Myco. d'Arf. équat. franc., 200, fig. 167, 1929; Geitler, Kryptogamenflora, 1048, fig. 661d, 1932.

= *Lepthothrix ochracea* Kütz., Phyc. gene., 198, 1843.

Thallus ochre yellow in colour; filaments densely aggregated; sheath at first thin and colourless, not coloured violet by chlor-zinc-iodide, later becoming coloured ochre; trichome distinctly constricted at the cross-walls, cross-walls granulated, 0.9 μ broad; cells 0.6–0.8 μ long blue-green; end cell rotund, without calyptra.

Floating in ponds, in tap water, in rivers, on mud and on submerged rocks — ponds in Choungmenah hills, Tankyeghat, Karen country (Martens, 1871b, 463) and near Natmadhi, Kya-Eng, Phounggye and Wha Choung in Burma (Zeller, 1873b, 169; 1873b, 176), Calcutta (Biswas, 1934, 12), River Moosi in Hyderabad (Ghousuddin, 1936, 150), Aruvikara, Travancore (Parukutty, 1940, 123) and River Hooghly at Calcutta (Biswas, 1942, 198).

35. **Lyngbya calcifera** Bruhl et Biswas

Indian Bark Algae, J. Dept. Sci., Calcutta Univ., 5: 12, pl. 4, figs. 15a-f, 1923; Biswas. The subaerial algae of the Berkuda island in the Chilka lake, Ganjam Dist., Madras Presidency, J. Proc. Asiatic Soc., Bengal, 20: 363, 1924; Geitler, Kryptogamenflora, 1050, 1932.

Pl. 55, Fig. 7

Filaments at first aggregated into small roundish clusters, 1–2 mm. in diam., which finally fuse into an extensive lichen-like, 0.5–2 mm. thin pustulate stratum, ash grey when dry, rather black when wetted; filaments incrusted by calcium carbonate, without the crust 8–10 μ thick, rough on the surface; cells about 4 μ in diam., 6–10 μ long, greenish blue, pretty uniformly finely granular.

On the barks of trees and on walls etc., Calcutta (Bruhl and Biswas, *loc. cit.*, and Biswas, 1924).

36. **Lyngbya palmarum** (Martens) Bruhl et Biswas

Indian Bark Algae, J. Dept. Sci., Calcutta Univ., 11, pl. 4, fig. 14, 1923. = *Scytonema palmarum* Martens, a third list of Bengal Algae, Proc. Asiatic Soc. Bengal, 39: 11, 1870a.

Pl. 55, Fig. 6

Thallus extensive, densely tomentose, dark coloured, when dried pale blue-green, or pale yellowish; filaments creeping or ascending, suberect and flexuous, loosely or closely intertwined, with sheath 6–10 μ broad; sheath at first dull coloured later brownish, 0.6–1 μ thick; trichome not constricted at the joints, apices rotund, scarcely attenuated; cells 4.5–8 μ long (c: b: 8.8, 6.6, 8.6); contents densely granulated, septa rarely conspicuous, hidden by granules, septa not marked by series of granules; apical cell without a thickened outer membrane.

Bot. Gardens, on palms, Calcutta.

### 37. **Lyngbya aureo-fulva** W. et G. S. West

Welwitsch's F. W. Afr. Algae, J. Bot., Lond., 35: 298, 1897; Forti in De Toni, Sylloge Algarum, 5: 277, 1907; Frémy, Myxo. d'Afr. équat. franc., 184, 1929; Geitler, Kryptogamenflora, 1051, 1932.

Thallus spongy, membranous, more or less yellow; filaments prominently coiled, 13.5–14.5 μ broad; sheath firm, smooth yellow to brown; trichome blue-green, slightly constricted at the cross-walls, 8.5–9.5 μ broad, not attenuated at the ends; cells nearly quadrate or somewhat longer than broad.

On soil in Cherrapunji plateau mixed with other terrestrial algae, Assam (Biswas, 1934, 13). The filaments in the Assam alga are 10–15 μ broad and the sheath is lamellated with 3–4 lamellae.

### 38. **Lyngbya dendrobia** Bruhl et Biswas

Indian Bark Algae, J. Dept. Sci., Calcutta Univ., 5: 8, pl. 3, fig. 11a–d, 1923; Geitler, Kryptogamenflora, 1051, 1932.

Pl. 50, Figs. 3, 10 & Pl. 55, Figs. 2–4

Stratum more or less expanded, compact, thin, minutely and densely tomentose; filaments long and flexible; closely interwoven, with sheath 10–11 μ thick; sheath usually thin, 1–1.5 μ thick, smooth, hyaline, usually colourless, more rarely when old brownish and very moderately stratified; trichomes 9–10 μ broad, scarcely or not at all constricted at the cross-walls; cells 1.7–2.5 times as broad as long, 4–6 μ long; contents of various shades of brown, uniformly and densely granular; dissepiments conspicuous, not marked by granules.

On the barks of various trees, Calcutta, Lucknow and Burdwan (Bruhl and Biswas, *loc. cit.*).

Drouet (The Brazilian Myxophyceae I, Amer. J. Bot., 24: 602, 1937) places this species under *Porphyrosiphon notarisii* (Menegh.) Kütz. But Skuja (1949, 55) retains this species.

#### forma **lurida** Bruhl et Biswas

Bruhl and Biswas, *loc. cit.*, p. 8, 1923.

Cells 10–12 μ diam., 6–8 μ long; sheath 0.6 μ thick, broad, hyaline.

On barks of trees, Bengal (Bruhl and Biswas, *loc. cit.*).

Rao, C. B., (The Myxophyceae of the United Provinces, Proc. Indian Acad. Sci., B, 6: 372, 1937b.) describes a form.

Filaments 9.6–13.2 μ broad; sheath thicker, 0.8–3 μ thick; trichome narrower than type, 6.6–8.8 μ broad; cells 4–8 μ long.

On moist soil, Benaras (Rao, C. B., *loc. cit.*).

### Var. **skujaii** nom. nov.

= *L. dendrobia* var.?, Skuja, Zur Süsswasseralgenflora Burmas, 52, pl. 8, figs. 28–30, 1949.

Filaments variously long, more or less irregularly coiled, sometimes also straight, 6.5–7 μ broad; sheath firm and smooth, very thick, about 0.9 μ thick, not gelatinised, sometimes with distinct parallel lamellation, generally colourless, occasionally light to dull ambre brown; trichome 4–6 μ broad, unconstricted or slightly constricted at the cross-walls, not attenuated at the ends; cells mostly as long as broad, also longer or shorter, ¾–1½ times the breadth, septa not granulated; end cell rounded and conical, with a somewhat thickened outer membrane.

On *Mangifera indica*, Rangoon, Burma (Skuja, 1949, 52).

Skuja doubts whether his Rangoon alga belonged to a separate variety. It differs from the type in the thinner filaments and trichomes, in the shape of the terminal cells and in the presence of a thinner outer membrane on the apical cell.

### 39. **Lyngbya corticicola** Bruhl et Biswas

Indian Bark Algae, J. Dept. Sci., Calcutta Univ., 5: 9, pl. 4, fig. 13a–c, 1923; Geitler, Kryptogamenflora, 1052, 1932.

Pl. 55, Fig. 5

Thallus a thin tomentose dark or yellowish brown layer; filaments somewhat fragile, moderately flexuous, more or less densely intricate, 12–26 μ thick, sheath at first hyaline, but later becoming brown, 2 μ thick; scarcely or not at all lamellated, surface uneven, not wrinkled; trichomes 8–12 μ broad, slightly constricted at the joints, cells about ½–⅓ as long as wide, apex rotund, contents green, granular, dissepiments not granulated.

On the barks of *Terminalia catappa*, Calcutta (Bruhl and Biswas, *loc. cit.*).

Rao, (The Myxophyceae of United Provinces, III, Proc. Indian Acad. Sci., B, 6: 372, 1937b) describes a form.

Filaments 18.4–25.6 μ broad; sheath very thick, stratified, 2.4–8 μ thick; trichome 10.4–12.8 μ broad, cells 4–8 μ long.

On moist soil, Benaras (Rao, C. B., *loc. cit.*).

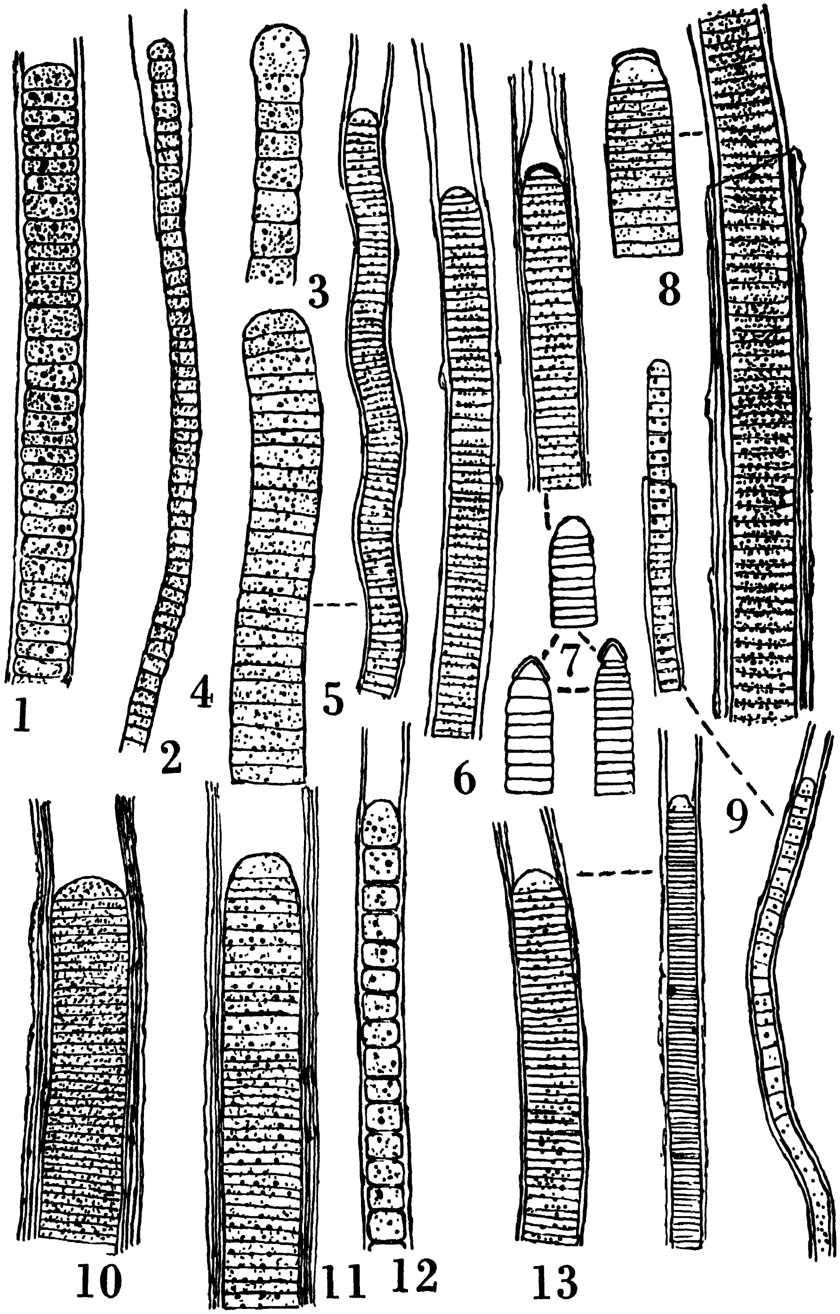

PLATE 52, Figs. 1–13.

1. *Lyngbya sordida* (Zanard.) Gom.; 2. *L. gracilis* Rabenh.; 3. *L. baculum* Gom.; 4, 5. *L. spirulinoides* Gom.; 6. *L. martensiana* Menegh.; 7. *L. semiplena* Ag.; 8. *L. aestuarii* Liebm.; 9. *L. lutea* (Ag.) Gom.; 10. *L. majuscula* Harv.; 11. *L. major* Menegh.; 12. *L. putealis* Mont.; 13. *L. confervoides* Ag. (all after Gomont).

### 40. **Lyngbya arboricola** Bruhl et Biswas

Indian Bark Algae, J. Dept. Sci., Calcutta Univ., 5: 7, pl. 13, figs. 10a-e 1923; Geitler, Kryptogamenflora, 1053, 1932.

Pl. 50, Fig. 3 and Pl. 55, Fig. 1

Thallus forming a continuous layer, when moist blue-green, when dry more or less reddish brown, velvetty; filaments nearly straight or moderately flexuous, long, 18–22 μ broad; sheath colourless at first or when empty, mostly reddish brown, firm, 1.5–2 μ thick, homogeneous or slightly stratified, often slightly transversely wrinkled; trichome shallowly but distinctly constricted at the septa, septa not granulated, blue-green, rounded at the extremity; cells usually 5–6 sometimes 6–10 μ long, contents, blue-green, densely granular; hormogones 2(?) to 20-celled.

On the barks of trees especially *Mangifera indica*, Calcutta (Bruhl and Biswas, *loc. cit.*); Benaras (Rao, C. B., 1937b, 372) and Madras (Rao, C. B., 1938a, 94).

Drouet (Brazilian Myxophyceae I, Amer. J. Bot., 24: 602, 1937) places this under *Porphyrosiphon notarisii* (Menegh.) Kütz. According to Rao, C. B., the filaments are 19.8–26 μ broad, the trichomes 16–17.5 μ broad and the sheath 2–4 μ thick.

### 41. **Lyngbya aestuarii** Liebm. ex Gomont

Liebmann, Bemerkninger og Tillag til den danske Algeflora, Kröyers Tidsskrift, 492, 1841; Gomont, Monogr. Oscillariées, 127, pl. 3, figs. 1, 2, 1892; Forti in De Toni, Sylloge Algarum, 5: 262, 1907; Frémy, Myxo. d'Afr. équat. franc., 183, fig. 152, 1929; Geitler, Kryptogamenflora, 1052, fig. 666, 1932; Frémy, Cyano. cotes d'Eur., 104, pl. 27, 1933.

Pl. 52, Fig. 8

Filaments single or forming a brown or dull blue-green thallus, sometimes having false branches, nearly straight or coiled, sometimes with calcium incrustations; sheath at first thin, later thick, yellow brown, lamellated, only sometimes brownish on the inside and colourless outside, not coloured violet by chlor-zinc-iodide; cells 8–24 μ, ordinarily 10–16 μ broad, $\frac{1}{3}$–$\frac{1}{6}$ times as long as broad, 2.7–5.6 μ long, not constricted at the cross-walls, cross-walls often granulated, contents sometimes with gas-vacuoles; end cells flat with thickened membrane, slightly attenuated.

Planktonic in lakes, ponds, rivers, and sea; on soil and epiphytic on sponges. — Dadar, Parel, Mahaluxmi, Matunga (Schmidle, 1900b, 161); Bandra (Gonzalves and Joshi, 1946, 168); in the sea near Bombay (Dixit, 1936, 104); Indian Ocean (Karsten, 1907, 402); Chilka lake (Biswas, 1932b, 188; 1932a, 318, 319); marine plankton at Krusadi island (Chacko, 1950, 166);

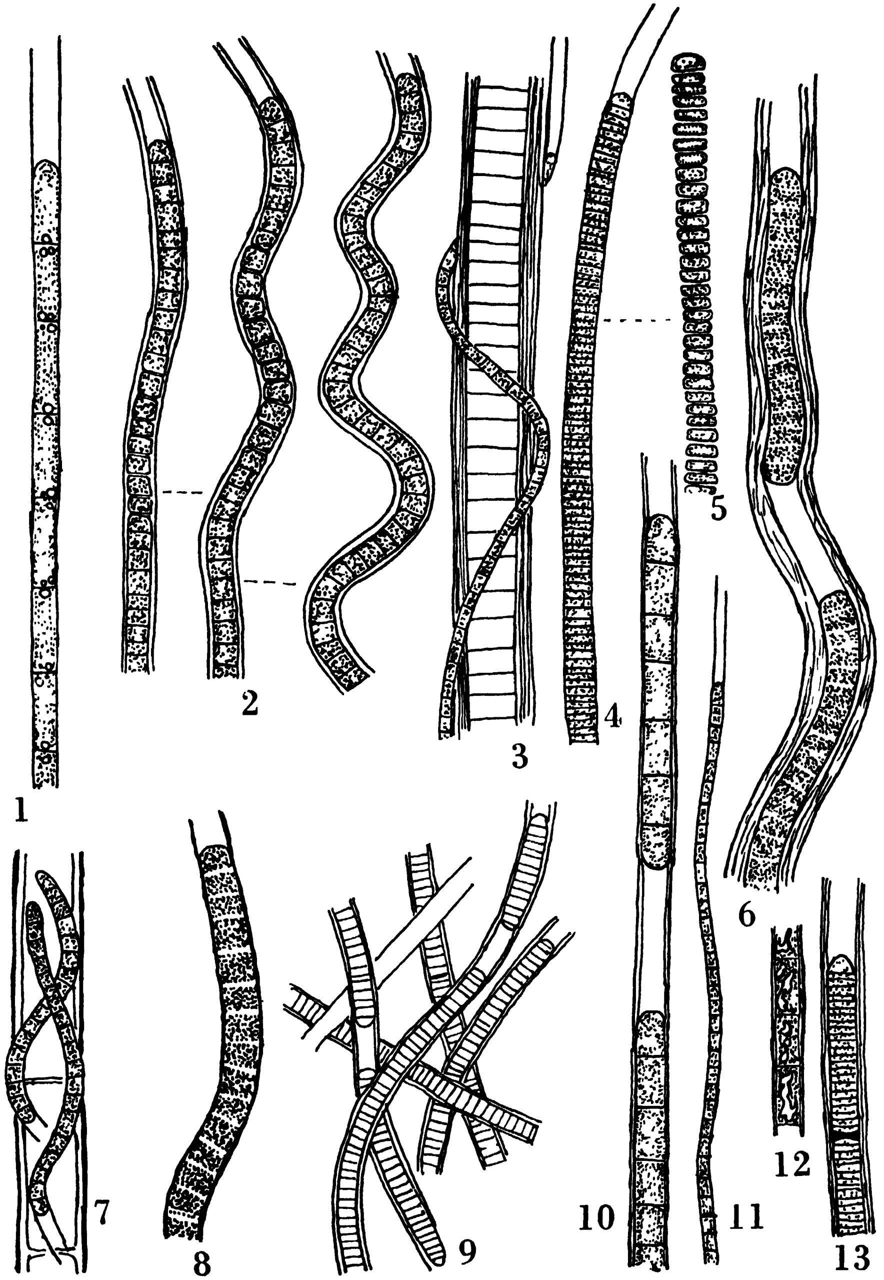

PLATE 53, Figs. 1–13.

1. *Lyngbya perelegans* Lemm. (after Frémy); 2. *L. lagerheimii* (Mobius), Gom. (after Frémy); 3, 11. *L. porphyrosiphonis* Frémy (after Frémy); 4, 5. *L. polysiphoniae* Frémy (after Frémy); 6. *L. versicolor* (Wartmann) Gom. (after Frémy); 7. *L. epiphytica* Hieron. (after Frémy); 8. *L. digueti* Gom. (after Frémy); 9. *L. martensiana* var. *calcarea* Tilden. (after Tilden); 10. *L. rubida* Frémy (after Frémy); 12. *L. borgerti* Lemm. (after Lemmermann); 13. *L. shackletoni* West et West (after West & West).

River Hooghly at Calcutta (Biswas, 1942, 196, 198); in rice and wheat field soil, Allahabad and red soil, Vandalur near Madras (Mitra, 1951, 359/360); on sponge *Laxodermites suborites* (Biswas, 1936, 128); Lahore (Ghose, 1919, 10; 1924, 339).

The filaments vary from 13–40 µ and the trichomes 8–16 µ in breadth.

Forma *spectabilis* Gom. is known from the Vajreshwari Hot Springs (34°–36°C) near Bombay (Gonzalves, 1947, 26)—filaments 38.6–41.5 µ broad, cells 5–6 µ long. F. *symplocoides* Gom. and f. *spectabilis* Gom. are distinguished from the type on the nature of the mature colony or on sheath characters. There are in all six forms in the species. Geitler, however, considers that these forms are mainly based on sheath characteristics which are highly variable.

Var. **arbustiva** Bruhl et Biswas

Indian Bark Algae, J. Dept. Sci., Calcutta Univ., 5: 5, pl. 2, figs. 9a–c, 1923.

Pl. 51, Fig. 10

Thallus extensive, felty, 1–10 mm thick, when dry of brown tints, when wetted by rain bluish-green; filaments long, flexible, at the base more or less prostrate, sinuous more or less densely interwoven; sheath at first thin and colourless, later on greyish or reddish brown, 20–28 µ in external diameter, 2–5 µ thick, rough on the outer surface, lamellose, the number of lamellae being 2–10; trichomes 17–18 µ in diam., scarcely or not at all constricted at the joints; cells usually 4–6 rarely 9 µ long; contents pale emerald-green, densely granular, granules partly minute, partly somewhat larger, often more crowded near the dissepiments.

On the barks of trees, Calcutta and Madras (Bruhl and Biswas, 1923, 5; Rao, C. B., 1937b, 372); in soil cultures from Khandala paddy-field, Bombay Presidency (Gonzalves and Gangla, 1949, 54).

Var. **constricta** Ghose

On some Myxophyceae of Rangoon, J. Burma Res. Soc. 15: part 3, 248, pl. 6, fig. 10, 1926.

Pl. 51, Fig. 9

Thallus brownish green; filaments copiously flexuous, incrusted, 30–33 µ broad; sheath at first thin, and hyaline, thin thick and lamellose, and yellowish brown, not turning blue by chlor-zinc-iodide; trichomes 20–22 µ broad, clearly constricted at the cross-walls, septa not granulated, apex slightly attenuated, round with a thickened wall.

As small free-swimming wads entangled to submerged aquatic plants, Royal lakes, Rangoon (Ghose, 1926, 248; 1927, 79).

### Var. **tenuis** Dixit

The Myxophyceae of the Bombay Presidency-I, Proc. Indian Acad. Sci., B, 3: 104, 1936.

Filaments 9–12.5 μ diam.; trichomes 5–9 μ broad; cells 1.25–2.5 μ long, no gas-vacuoles, cross-walls granulated.

Along with *Chara* in a freshwater pond inundated by sea water in high tide, Bhayander, Bombay State (Dixit, *loc. cit.*).

### 42. **Lyngbya connectens** Bruhl et Biswas

Indian Bark Algae, J. Dept. Sci., Calcutta Univ., 5: 4, pl. 2, figs. 8a-e, 1923; Geitler, Kryptogamenflora, 1053, 1932.

Pl. 51, Figs. 5, 6, 11

Stratum extensive, about 1 mm thick, when dry shining and dark green; filaments straight or nearly so, lying parallel to each other, the trichome often creeping out of their entire sheath; sheath at first delicate and colourless, but later when old, becomes firm and brownish, 1.5–2 μ thick, nearly lamellate with 2–3 lamellae; trichomes 12–17 μ broad, not constricted at the cross-walls, slightly thickened at the apex, cells about 1/6 as long as broad, 2–2.5 μ long; dissepiments granulated, contents granular, verdigris-green.

On the barks of *Ficus infectoria* and *Ficus* sp., Calcutta and Lucknow (Bruhl and Biswas, *loc. cit.*).

### 43. **Lyngbya truncicola** Ghose

A systematic and ecological account of a collection of blue-green algae from Lahore and Simla, J. Linn. Soc., Bot., 46: 339, pl. 31, fig. 6, 1924; Geitler, Kyrptogamenflora, 1054, 1932.

Pl. 51, Fig. 4

Thallus thin, expanded, blue-green; filaments straight, more or less parallel, 14–16 μ broad; sheath at first hyaline, and delicate, later firm and yellowish, unlamellated; trichome blue-green, 12–14 μ broad, not constricted at the cross-walls, cell-walls not granulated; cells short, 3–4 μ long, contents granular; apical cell rotund, not attenuated, calyptra none.

On tree trunks — on *Acacia modesta* at Lahore (Ghose, *loc. cit.*), on *Bassia latifolia* and *Mangifera indica,* Benaras (Rao, C. B., 1937b, 373).

According to Rao, C. B. (*loc. cit.*) the trichomes are 12–15 μ broad, the sheath about 0.8 μ thick and the cells 1.5–4.5 μ long.

Var. **burmense** Ghose

Myxophyceae of Rangoon, I, J. Burma Res. Soc., 15: 247, 1926.

Pl. 51, Fig. 7

Thallus bluish green when moist and more or less reddish brown when dry, velvetty forming a continuous layer consisting of living filaments and empty sheaths; filaments, flexuous, intricate, 13–15 μ thick; sheath colourless at first but becoming reddish brown later, not lamellated; trichome not constricted at the cross-walls, 11–12 μ thick; cells generally quadrate, sometimes shorter or longer than broad; cross-walls granulated; apex rotund, not attenuated.

On the barks of a number of trees, Rangoon, Mergui island and Kisseraing island, Burma (Ghose, 1926, 247; 1927c, 249; 1927e, 81); on soil on the top of the hills at Shillong, Assam (Biswas, 1934, 12).

### 44. **Lyngbya erebi** W. et G. S. West

Brit. Antarctic Exped., 1, 1911; Geitler, Kryptogamenflora, 1056, 1932.

Thallus expanded, 3–5 mm thick, dull blue-green to nearly colourless; filaments densely intricate 0.9 μ broad; sheath thin and delicate; trichome straight, not attenuated at the ends.

In cultures of paddy-field soil, Goregaon near Bombay (Gonzalves and Gangla, 1949, 54).

The record of this species in the tropics is interesting. The species itself is incompletely described.

### 45. **Lyngbya perelegans** Lemm.

Planktonalg., Ergebnisse einer Reise n. d. Pacific, Abh. nat. Ver. Bremen, 16: 355, 1899; *ibid.*, 18: 153, pl. 11, figs. 13–14, 1904; Kryptogamenflora der Mark Brandenburg, 3: 138, 1910; Forti in De Toni, Sylloge Algarum, 5: 289, 1907; Frémy, Myxo. d'Afr. équat. franc., 199, fig. 166, 1929; Geitler, Kryptogamenflora, 1056, fig. 66a-c, 1932.

Pl. 48, Fig. 8 & Pl. 53, Fig. 1

Thallus with many entangled, straight or curved filaments; filaments 1.5–2 μ broad; sheath thin, hyaline; trichomes 1–1.5 μ broad, not constricted at the cross-walls, cross-walls with a single granule on either side; cells 2–8 μ long, pale blue-green, end cell rotund, not attenuated.

Attached to submerged aquatic plants and other objects in tanks and on the bottom mud — Kan-gyi (West and West, 1907, 24) and Rangoon in Burma (Ghose, 1926, 248; 1927; 79); Lahore (Ghose, 1924, 339); Punjab and N. India (Randhawa, 1936c, 42).

### 46. **Lyngbya lutea** (Ag.) Gom.

Essai class. Nostoch. homocystées, Morots J. Bot., 4: 354, 1890; Monogr. Oscillariées, 161, pl. 3, figs. 12, 13, 1892; Forti in De Toni, Sylloge Algarum, 5: 275, 1907; Frémy, Myxo. d'Afr. équat. franc., 189, 1929; Geitler, Kryptogamenflora, 1057, fig. 670a, b, 1932; Frémy, Cyano. cotes d'Eur., 109, pl. 28, fig. 4, 1933.

Pl. 52, Fig. 9

Thallus somewhat gelatinous, leathery, yellowish brown to olive-green, when dry often dark violet; filaments coiled and densely entangled; sheath colourless, smooth at first thin, but later up to 3 μ thick and lamellated, coloured violet by chlor-zinc-iodide; trichome not constricted at the cross-walls, not attenuated at the ends, 2.5–6 μ broad, olive-green, cross-walls granulated; cells quadrate to 1/3 times as long as broad, 1.5–5. μ long; end cells with rounded calyptra.

Tycholimnetic in tank or in ponds, in drains — Trincomalie, Ceylon (Crow, 1923b, 142); Benaras (Rao, C. B., 1937b, 373) and Delhi (Rao, C. S., 1940, 131).

The filaments are 5–7.6 μ broad in the Indian materials.

### 47. **Lyngbya scotti** Fritsch

Brit. nat. Antarctic Exped., Nat. Hist., 6: p. 29, pl. 2, figs. 91–93, 1912; Geitler, Kryptogamenflora, 1058, figs. 670c–e, 1932.

Filaments mostly prominently coiled, occasionally nearly straight forming a thallus, 3.4–5 μ broad; sheath at first thin and colourless, later thicker, outer surface rough, unlamellated; trichome attenuated at the ends, not prominently constricted at the cross-walls, 2.6–3 μ broad; end cell prominently conical, not capitate, without calyptra; cells as long as broad or somewhat longer.

In culture of paddy-field soil from Thana near Bombay (Gonzalves and Gangla, 1949, 54).

### 48. **Lyngbya digueti** Gomont

In Hariot, Algues du Golfe de Californie recuilles, J. de Bot., 9: 169, 1895; Forti in De Toni, Sylloge Algarum, 5: 284, 1907; Frémy, Myxo. d'Afr. équat. franc., 196, fig. 163, 1929; Geitler, Kryptogamenflora, 1058, fig. 656a, 1932.

Pl. 53, Fig. 8

Filaments forming a caespitose, light green, 2 mm thick thallus, tortuous and entangled in their basal portions, at the ends straight, 2.5–3 μ broad;

sheath thin, colourless, papyraceous coloured violet by chlor-zinc-iodide; trichome not constricted at the cross-walls, 2–3 μ broad; cells nearly quadrate or seldom shorter than broad, 1–3.7 μ long; end cell rotund, without calyptra.

In the environs of Shembaganur (Frémy, 1942, 21).

Rao, C. B. (1937b, 373) reports a form from a pond in Benaras which has narrower filaments (1.5–2.3 μ broad) and trichomes (1.4–2.2 μ broad). Banerji (1938, 105) describes another form of this species with constricted trichomes and shorter cells (1–1.5 μ long).

### 49. **Lyngbya kuetzingiana** Kirchner

Kryptogamenflora von Schlesien, Algen, 242, 1878; Forti in De Toni, Sylloge Algarum, 5: 278, 1907; Geitler, Kryptogamenflora, 1059, 1932; *non* Thuret.

= *Phormidium obscurum* Kutz., Phyc. germ., 162, 1845; *non* Rabenh. 1865.

Thallus caespitose and lamellose, outside bright blue-green to olive-green, inside more or less colourless; filaments 3.6–5 μ broad, coiled; trichomes 3.5–4 μ broad, constricted at the cross-walls only at the ends of the trichome, cross-walls granulated, cells as long as broad, blue-green; end cell obtuse or rotund.

On the barks of trees and on soil. — Kamaw and Kisseraing islands, Burma (Ghose, 1927c, 249); paddy-field soils from Bombay suburbs (Gonzalves and Gangla, 1949, 54).

### 50. **Lyngbya versicolor** (Wartm.) Gom.

Monogr. Oscillariées, 147, pl. 4, figs. 4, 5, 1892; Forti in De Toni, Sylloge Algarum, 5: 282, 1907; Frémy, Myxo. d'Afr. équat. franc., 198, fig. 164, 1929; Geitler, Kryptogamenflora, 1059, fig. 656f, 1932.

Pl. 53, Fig. 6

Thallus at first adherent, later free-floating, lubricous, somewhat soft, rusty on the outside and inside olive-green; filaments long, tortuous, closely entangled; sheath colourless, somewhat yellowish, slightly mucilaginous, up to 2 μ thick, coloured violet by chlor-zinc iodide; trichomes not constricted at the cross-walls, 2.8–3.2 μ broad, apices not attenuated, not capitate, cross-walls not granulated; cells blue-green, 2–6.4 μ long, end cell rounded, calyptra absent.

In an artificial tank, Perediniya, Ceylon (West and West, 1902, 204).

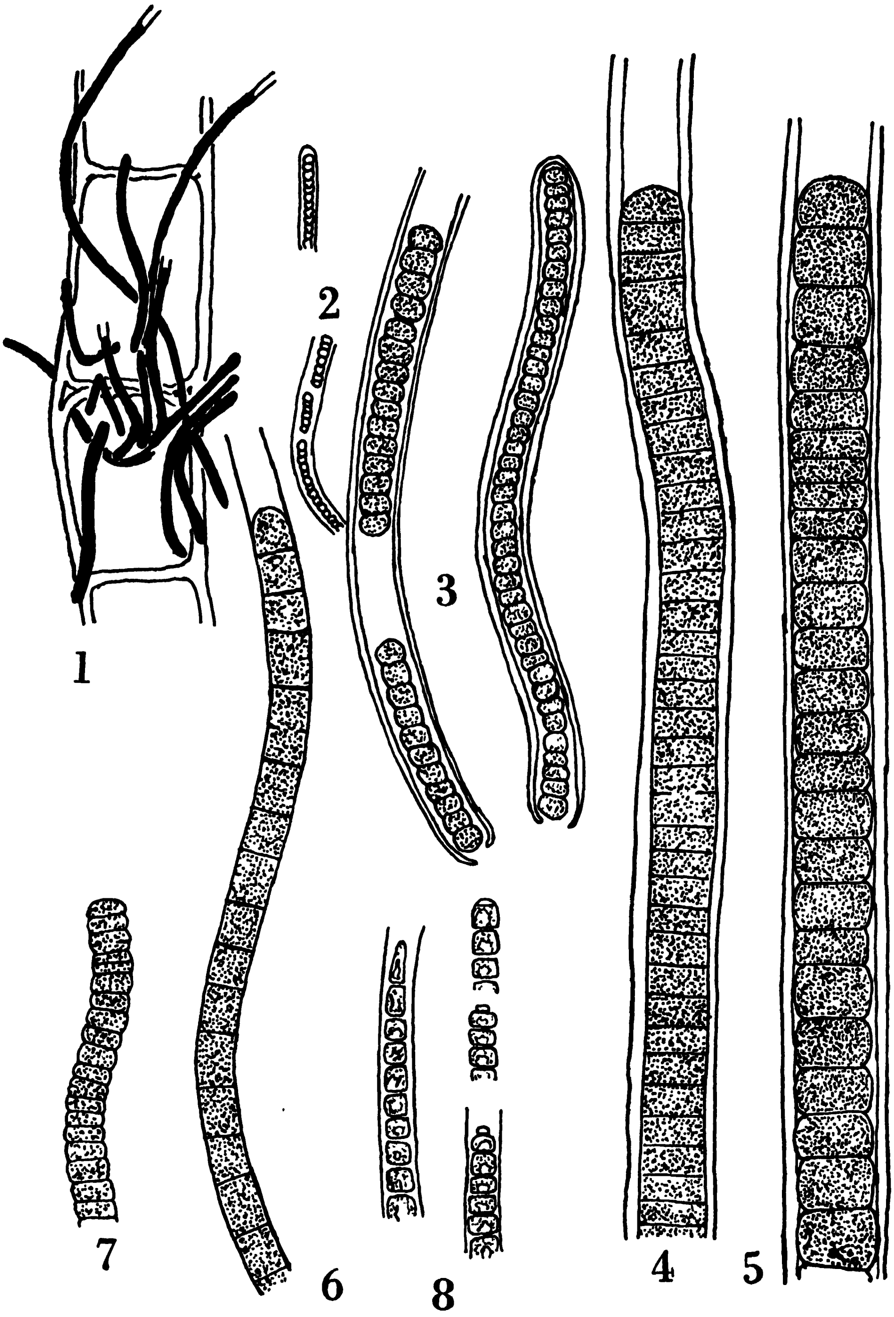

PLATE 54, Figs. 1–8.

1, 2 & 3. *Lyngbya nordgardhii* Wille (1, 2 after Wille & 3 after Frémy); 4. *L. ceylanica* Wille (after Frémy); 5. *L. ceylanica* v. *constricta* Frémy (after Frémy); 6. *L. allorgei* Frémy (after Frémy); 7. *Phormidium jenkelianum* Schmid, G. (after Schmid); 8. *P. dimorphum* Lemm. (after Lemmermann).

51. **Lyngbya porphyrosiphonis** Frémy

Cyanophycées de l'Inde méridionale, Blumea, suppl. 2: 21–40, 1942.

Pl. 53, Fig. 3

Filaments growing amidst *Prophyrosiphon notarisii* Kütz., sparse more or less flexuous, growing irregularly round *P. notarisii* filaments, about 2.7 μ broad; sheath hyaline, homogeneous, thin, not coloured violet with chlor-zinc-iodide; trichomes about 2 μ broad, not constricted at the cross-walls; cells 1.5–2 times as long as broad, contents bluish-grey, finely granular; cross-walls prominent; apical cell rotund or obtusely conical, not capitate.

In the environs of Shembaganur (Frémy, *loc. cit.*).

52. **Lyngbya allorgei** Frémy

Myxo. d'Afr. équat. franc., 189, fig. 156, 1929; Geitler, Kryptogamenflora, 1059, fig. 671, 1932.

Pl. 54, Fig. 6

Filaments solitary or united and caespitose, fasciculate; tortuous, intricate, elongate; sheath very thin, papyraceous, colourless, not coloured violet by chlor-zinc-iodide; trichome pale violet, not constricted at the cross-walls, 3.5–4 μ broad, cells nearly quadrate or up to 1 1/2 times as long as broad, cross-walls not granulated; end cell rotund, calyptra absent.

On mud and stones submerged in flowing waters, Borivli, Bombay (Dixit, 1936, 104).

According to Dixit, the trichome in the Bombay alga is 4.6–6.4 μ broad and the cells are 4.6–8.3 μ long.

53. **Lyngbya majuscula** Harvey ex Gomont

Harvey in Hooker, English Flora, 5 (part 1) : 370, 1833; Gomont, Monogr. Oscillariées, 151, pl. 3, figs. 3, 4, 1892; Forti in De Toni, Sylloge Algarum, 5: 268, 1907; Geitler, Kryptogamenflora, 1060, figs. 672c, d, 1932; Frémy, Cyano. cotes d'Eur., 106, pl. 28, fig. 1, 1933.

Pl. 48, Fig. 7, Pl. 49, Fig. 12 & Pl. 52, Fig. 10

Thallus expanded, up to 3 cm long, dull blue-green to brown or yellowish brown; filaments very long, curved or seldom only slightly coiled; sheath colourless, lamellated up to 11 μ thick, outside often rough, not coloured violet by chlor-zinc-iodide; trichome blue-green, brownish green or grey violet; not constricted at the cross-walls, not attenuated at the ends, 16–60 μ (or up to 80 μ) broad, mostly 20–40 μ broad; cells very short 1/6–1/5 times as long as broad, 2–4 μ long, cross-walls not granulated; end cells rotund, calyptra absent.

In both fresh and sea water situations in India, Burma and Ceylon. Not so far reported from Pakistan.

The writer has collected in a few more freshwater localities in Madras, Tirupati etc. ( ! ).

Weber van Bosse recorded trichomes with up to 80 μ breadth, though commonly they are 16–60 μ broad. In India the trichomes have been reported anywhere from 6.5–9.9 up to 40 μ broad. Rao, C. B. (1936, 172) describes a variety, var. *chakiaense* (var. *chakiaensis* writes J. De Toni) from the United Provinces which differs from the type in the longer cells (4–7.6 μ average 6 μ) and the much thinner sheath (Pl. 51, Fig. 1). The species is so variable, that it is doubtful whether one can really separate subordinate taxa with any degree of certainty. For example, the sheath in the type is up to 11 μ thick, and in var. *chakiaensis* about 3.8–5.2 μ thick. The same author, surprisingly enough, later (1938b, 169) reports specimens of the same variety with 5–6.6 (–10) μ thick sheath (cf. also Rao, C. S. 1939, 150). The length of the cells does similarly vary (3.5–7.5 μ even rarely up to 10 μ long) according to whether it is prior to or after transverse division.

### 54. **Lyngbya confervoides** C. Ag. ex Gomont

C. Agardh, Syst. Alg., 73, 1824; Gomont, Monogr. Oscillariées, 156, pl. 3, figs. 5–6, 1892; Forti in De Toni, Sylloge Algarum, 5: 271, 1907; Geitler, Kryptogamenflora, 1061, fig. 672b, 1932; Frémy, Cyano. cotes d'Eur., 106, pl. 28, fig. 2, 1933.

Pl. 49, Fig. 9 & Pl. 52, Fig. 13

Thallus caespitose, fasciculate, up to 5 cm in height, yellowish brown or dull green, when dried often violet; filament at the base decumbent, above ascending and entangled, straight; sheath colourless, when old lamellated, outside rough up to 5 μ thick, not coloured violet by chlor-zinc-iodide; trichome olive-green or blue-green, not constricted at the cross-walls, cross-walls commonly granulated, not attenuated at the apices, 9–25 μ mostly 10–16 μ broad; cells 1/3–1/8 times as long as broad, 2–4 μ long; end cell rotund, calyptra absent.

In sea water around the coasts of Bombay (Boergesen, 1935, 7; Dixit, 1936, 104) and Krusudai island (Iyengar and Desikachary, 1944, 62), in the estuarine lake, Chilka (Biswas, 1932b, 189); in freshwater ponds and puddles, Benaras (Rao, C. B., 1937b, 374); Cuttack (Rao, C. B., 1938b, 170); at Polamur, Namdur and Chittavaram in Andhra State (Rao, C. B., 1938a, 95) and at Khajiar in Punjab (Gupta, 1950, 111).

The filaments in the Indian material are 14–30 μ broad. In one case the trichomes have been described as very narrow, 6.5–10 μ broad (*see* Dixit, 1936, 104).

### 55. **Lyngbya cinerescens** Kütz.

Species Algarum, 281, 1849; Tab. Phycologicae, 1: pl. 88, fig. 3, 1849; Forti in De Toni, Sylloge Algarum, 5: 268, 1907.

Thallus light blue-green; trichome 7.5–15 μ broad, pale bluish, cells short; sheath thick, colourless.

On an old log of wood in brackish water, Salt lakes, Calcutta (Martens, 1871a, 172, also Prain, 1905, 333; Biswas, 1926, 23); on wet soils Newara Elliya, Ceylon (Zanardini, 1872, 162).

### 56. **Lyngbya semiplena** (C. Ag.) J. Ag. ex Gomont

Agardh, J., Algae maris Meditterranei et Adriatici, 11, 1842; Gomont, Monogr. Oscillariées, 158, pl. 3, ags. 7–11, 1892; Forti in De Toni, Sylloge Algarum, 5: 273, 1907; Geitler, Kryptogamenflora, 1061, fig. 672a, 1932; Frémy Cyano. cotes d'Eur., 108, pl. 28, fig. 3, 1933.

Pl. 49, Fig. 8 & Pl. 52, Fig. 7

Thallus caespitose, seldom above 3 cm long, mostly dark yellowish green, sometimes when dry dark violet; filaments at the base decumbent, growing erect by their ends and entangled, curved or flexuous; sheath colourless, slightly slimy, mucilaginous, when old lamellated, up to 3 μ thick, not coloured violet by chlor-zinc-iodide; trichome yellowish green or blue-green, not constricted at the cross-walls, cross-walls often granulated, at the ends slightly attenuated, capitate, 5–12 μ commonly 7–10 μ broad; cells 1/3–1/6 as long as broad, 2–3 μ long; end cell with a flat conical or roundish calyptra.

In a rocky puddle at sea-shore, Vizagapatam (Rao, C. B., 1938a, 95), on rocks in sea-shore at Dhanuskodi, Cape Comorin and Seven Pagodas (Iyengar and Desikachary, 1944, 63), in a stagnant pond, Veli, Travancore (Parukutty, 1940, 124), Cape Comorin (Venkataraman, 1957, 473).

The filaments in the Indian material are 12–18 μ broad and the trichomes are 6.5–13 μ broad.

### 57. **Lyngbya aerugineo-coerulea** (Kütz.) Gomont

Monogr. Oscillariées, 146, pl. 4, figs. 1–3, 1892; Forti in De Toni, Sylloge Algarum, 5: 281, 1907; Frémy, Myxo. d'Afr. équat. franc., 190, fig. 157, 1929; Geitler, Kryptogamenflora, 1062, fig. 670, 1932.

Pl. 48, Fig. 9

Filaments single or more rarely forming a dull blue-green expanded thallus, flexuous, fragile; sheath thin, firm, not lamellated, not coloured violet by chlor-zinc-iodide; trichomes 4–6 μ broad, not constricted at the cross-walls, sometimes granulated, apex of trichome occasionally capitate; cells 1–1/2

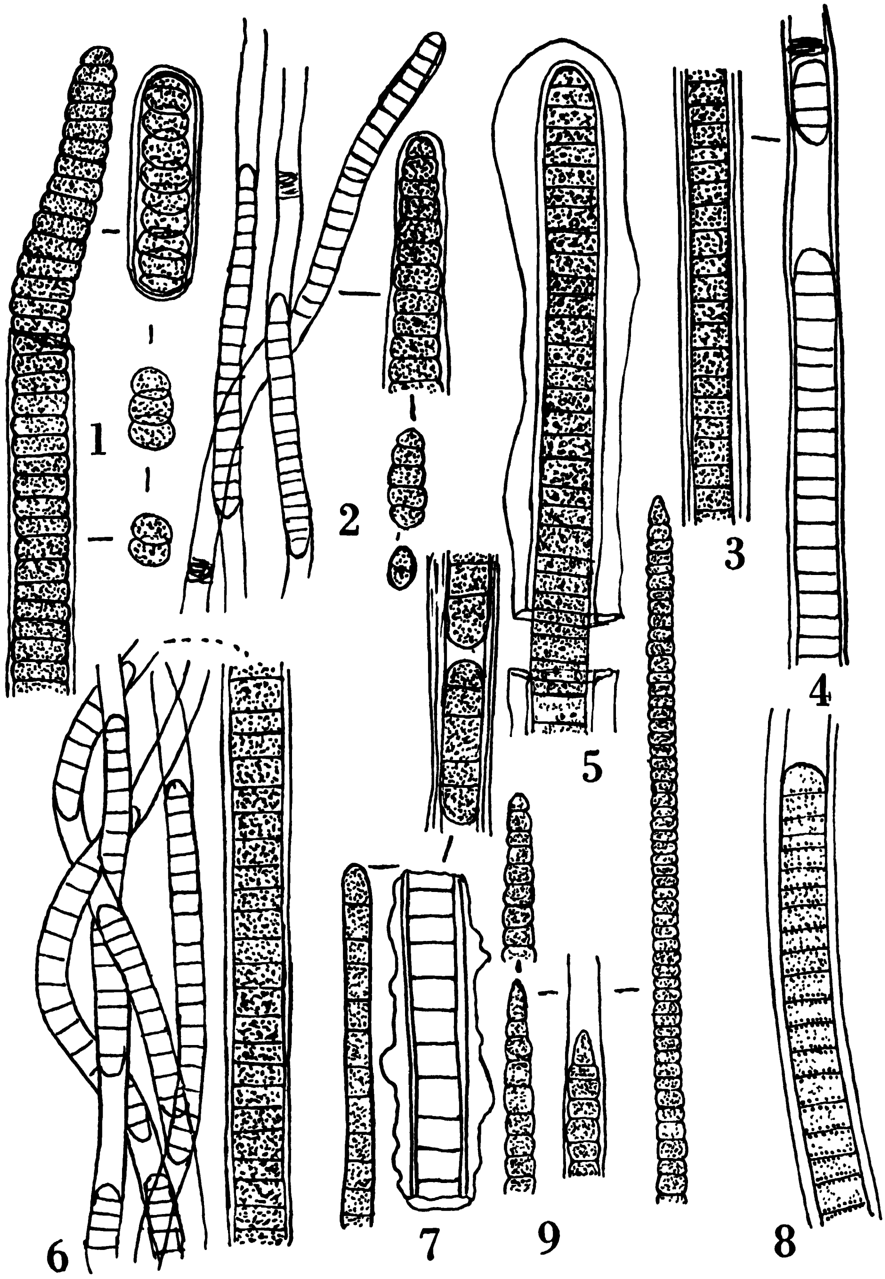

PLATE 55, Figs. 1–9.

1. *Lyngbya arboricola* Bruhl et Biswas (after Bruhl & Biswas); 2, 3, 4. *L. dendrobia* Bruhl et Biswas (after Bruhl & Biswas); 5. *L. corticicola* Bruhl et Biswas (after Bruhl & Biswas); 6. *L. palmarum* Bruhl et Biswas (after Bruhl & Biswas); 7. *L. calcifera* Bruhl et Biswas (after Bruhl & Biswas); 8. *L. hieronymusii* Lemm. v. *crassivaginata* Ghose (after Ghose); 9. *Phormidium jadinianum* Gom. (after Frémy).

as long as broad, 2.3–3 μ long, pale blue-green; end cell flattened, conical or rotund, with a slightly thickened outer membrane.

In stagnant and flowing waters, in cultures of paddy-field soils, on moist rocks soil, and on barks of trees.—Recorded from all over India, Pakistan and Burma.

The filaments are generally (5.6–) 6–8 μ broad in the Indian material.

Mitra A. K. (1951, 359/362) mentions of a new variety, var. *terrestris* (*nomen nudum*), from Indian soils but he does not give any description or figures.

### 58. **Lyngbya stagnina** Kützing

Species Algarum, 281, 1849; Tab. phycologicae, 1: 48, pl. 87, fig. 5, 1849; Geitler, Kryptogamenflora, 1066, 1932.

Thallus dull-green; filaments flexuous, 11–16 μ broad; sheath colourless or yellowish, lamellae 3, colored violet by chlor-zinc-iodide; trichome 9.5–12 μ broad, not constricted at the cross-walls, distinctly granulated at the cross-walls; cells 2–4 μ long; end-cell broadly rounded, not attenuated.

Type not recorded.

Boye-Peterson records a specimen which Geitler considers as capitate and calyptrate.

Rao, C. B. (1937b, 374) records a form from Benaras which differs in having narrower trichomes (8.5–9.5 μ) and longer cells. The septa are not granulated. It is possible that this form may belong elsewhere.

Forti (1907, p. 126) includes this species under *L. aestuarii*. But Lemmermann (Kryptogamenflora der Mark Brandenburg 3: 139, 1910) and Geitler (1932) recognise this species.

### 59. **Lyngbya nigra** C. Ag. ex Gomont

Agardh, C., Syst. Alg., 312, 1824; Gomont, Monogr. Oscillariées, 145, pl. 3, fig. 16, 1892; Geitler, Kryptogamenflora, 1063, fig. 675a, 1932.

Filaments long straight, forming an extensive caespitose dark green thallus; sheath thin, colourless not lamellated, not coloured violet by chlor-zinc-iodide; trichome 8–11 μ broad, not constricted at the cross-walls, septa not granulated, dull green, ends attenuated; cells 1/2–1/4 as long as broad, 2–4 μ long, contents granular, apical cell truncated and round.

Mouth of River Pandure, Ceylon (West and West, 1902, 204); in a roadside puddle, Coconada, Andhra Pradesh (Rao, C. B., 1938a, 95).

### 60. **Lyngbya putealis** Mont. ex Gomont

Montagne, 20 centurie de Plantes cellulaires exotiques, Ann. Sci. nat., 2 ser., Bot., 13: 200, 1840; Gomont, Monogr. Oscillariées, 143, pl. 3, fig. 14, 1892; Forti in De Toni, Sylloge Algarum, 5: 277, 1907; Frémy, Myxo. d'Afr. équat. franc., 193, fig. 159, 1929; Geitler, Kryptogamenflora, 1063, fig. 675, 1932.

Pl. 52, Fig. 12

Thallus caespitose, expanded, up to 1 cm long, penicillate, dull blue-green, when dry sometimes violet; filaments curved or nearly straight, at the base intricate, above more or less parallel; sheath thin, papyraceous, colourless, coloured violet by chlor-zinc-iodide; trichome 7.5–13 μ broad, distinctly constricted at the cross-walls, cross-walls sometimes granulated, not attenuated, not capitate, blue-green; cells quadrate of up to 1/3 as long as broad, 3–10 μ long; end cell rounded.

In stagnant and flowing waters, Ceylon (Ferguson ex Gomont, 1892, 163) and River Nalanda Oya near Nalanda, Ceylon (Crow, 1923b, 142); in muddy water canal, Minywa, Pegu, Burma (West and West, 1907, 241); in stagnant waters of irrigation channel, Benaras (Rao, C. B., 1937b, 274); on the steps of a tank, Berhampur, Orissa (Rao, C. B., 1938b, 170); in hot springs (40°–45°C) at Vajreshwari near Bombay (Gonzalves, 1947, 26).

In the specimens recorded from India the trichomes appear to be narrower (5–10 μ). The filaments are 8–11.2 μ broad.

### 61. **Lyngbya martensiana** Menegh. ex Gomont

Meneghini, Conspectus Algologiae euganeae, 12, 1837; Gomont, Monogr. Oscillariées, 145, fig. 17, pl. 3, 1892; Forti in De Toni, Sylloge Algarum, 5: 279, 1907; Frémy, Myxo. d'Afr. équat. franc., 191, fig. 158, 1929; Geitler, Kryptogamenflora, 1064, fig. 676, 1932; Frémy, Cyano. cotes d'Eur., 107, pl. 29, fig. 1, 1933, *non* Rabenh. 1865.

Pl. 52, Fig. 6

Thallus caespitose, blue-green, when dried violet, filaments long more or less flexible; sheath colourless, thick, not coloured violet with chlor-zinc-iodide outside rough; trichome 6–10 μ broad (rarely 13 μ), not constricted at the cross-walls, cross-wall sometimes granulated, apices not attenuated, pale blue-green; cells 1/2–1/4 times as long as broad, 1.75–3.3 μ in length; end cell rotund, without calyptra.

In a jhil at Imphal, Manipur, Assam (Biswas, 1930, 189); in a stagnant tank, Perukada, Travancore (Parukutty, 1940, 124); Rangoon (Skuja, 1949, 54).

Filaments in the Indian material are 9.5–16 μ broad; the cells are much longer than in the type (2–5 μ long).

Bharadwaja, (Myxophyceae of United Provinces, I, Proc. Indian Acad. Sci., B, 2 : 97, fig. 2A, 1935) describes a form.

Pl. 51, Fig. 2

Filaments single not in bundles, generally straight, up to 3 mm. long; sheath diffluent on the outside, up to 3.1 μ thick; trichomes about 10.5 μ broad; cells 2.1–5.2 μ long.

On dead leaves in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

Singh, V. P. (1941, 253) describes a form from Chamba in Punjab, which very much resembles Bharadwaja's form in having single filaments but differs in having shorter cells (filaments 8.4–11.5 μ broad; trichome 6.9–7.7 μ broad; cells 1.2–1.5 μ long). Rao's form from Benaras (1937b, 374) agrees well with the type and does not appear to be distinct and so does Banerji's form (1938, 106) from the salt lakes at Dhapa in Bengal. Both these forms appear to be based on the sheath being smooth, whereas in the type it becomes rough with age (*see* De Toni, 279, 1907).

### Var. **calcarea** Tilden

American Algae Cent. II, no. 178, 1896; Forti in De Toni, Sylloge Algarum, 5: 280, 1907; Tilden, Minnesota Algae, 1: Myxo., 125, pl. 5, fig. 44, 1910; Geitler, Kryptogamenflora, 1064, fig. 677, 1932.

Pl. 53, Fig. 9

Plant mass forming extended strata throughout upper portions of calcareous deposit; filaments 6.5–7.5 μ in diameter, straight, flexible, somewhat unequal in size; sheath very distinct, colourless, smooth or rough; trichomes 5–6.5 μ in diameter, not constricted at the joints, frequently interrupted; apex of trichome not or very rarely tapering; cells about 2.5 μ in length, contents dull blue-green, violet or rarely brown.

On cemented steps with constant waterfall, Gauhati, Assam (Parukutty, 1939, 235); free-floating in a pond, Delhi (Rao, C. S., 1940, 131).

### Var. **minor** Gardner

Mem. N. Y. Bot. Gdn, 7: 41, pl. 8, fig. 80, 1927; Geitler, Kryptogamenflora, 1064, fig. 675c, 1932.

Filaments 250–500 μ long, slightly bent, 7.2–8 μ broad, sheath colourless, not lamellated, smooth, about 2 μ thick; trichome 4.8–5 μ broad, not constricted at the cross-walls, bright blue-green, granulated at the cross-walls; cells very short, 1.4–1.8 μ long; end cell capitate.

In a pool, Allepey, Travancore (Parukutty, 1940, 124).

Parukutty's alga differs in having broader trichomes.

Geitler doubts whether the variety is capitate.

### 62. **Lyngbya corbierei** Frémy

Bull. Soc. Linn. Normandie, 7: ser. 6., 15, fig. 16, 1923; Geitler, Kryptogamenflora, 1065, fig. 678, 1932.

Thallus free-floating, blue-green; filaments more or less coiled; sheath colourless, lamellated, when old rough, and not coloured violet by chlor-zinc-iodide; trichome not constricted at the cross-walls, yellow green, attenuated at the ends, 9–10 μ broad, septa indistinct, granulated; cells 3.5–4 μ long; end cell rounded with calyptra.

In a rocky puddle on the hillock extending into the sea from the shore, Vizagapatam (Rao, C. B., 1938a, 96).

The trichome in the Vizag material is 7–9.9 μ broad and the filaments are 10.4–12.8 μ broad; the cells are 3.2–5.6 μ long.

### 63. **Lyngbya magnifica** Gardner

New Myxophyceae from Porto Rico, Mem. N. Y. Bot. Gdn, 7: 40, pl. 8, fig. 79, 1927; Geitler, Kryptogamenflora, 1067, fig. 680b, 1932.

Filaments long, straight and rigid, 32–40 μ broad, forming a thin and loose layer or stratum; sheath 2–2.5 μ thick, colourless, smooth, unlamellated; trichome 28–36 μ broad, not attenuated at the ends, not constricted at the cross-walls, purple violet; cells 3.8–5 μ long; end cell rounded, outer membrane slightly thickened.

In a tank, Veli, Travancore (Parukutty, 1940, 124).

The Indian alga is smaller (filaments 25–36 μ broad, trichome 20–33 μ broad, cells 3.5–6.6 μ long.)

### 64. **Lyngbya major** Menegh. ex Gomont

Meneghini, Conspectus Algologiae euganeae, 12, 1837; Gomont, Monogr. Oscillariées, 144, pl. 3, fig. 15, 1892; Forti in De Toni, Sylloge Algarum, 5: 279, 1907; Geitler, Kryptogamenflora, 1066, fig. 679a, 1932. *non* Kütz., *non* Rabenh.

Pl. 52, Fig. 11

Filaments long, straight forming dark-green caespitose bundles; sheath thick; colourless, lamellated, not coloured violet by chlor-zinc-iodide; cells 11–16 μ broad, 1/4–1/8 as long as broad, 2–3.4 μ long, dull blue-green, granulated at the septa, slightly or not constricted at the cross-walls; end cell rounded with a slightly thickened membrane.

In ponds, tanks, in marshes and on soil. — Perediniya and Trincomalie in Ceylon (West & West, 1902, 204; Crow, 1923b, 142); Mausang near Hsipan, in Burma (West & West, 1907, 241); Benaras (Rao, C. B., 1937b, 375); Coconada (Rao, C. B., 1938a, 96) and Calcutta (Banerji, 1938, 106).

Rao (1938a, 96) reports the trichome as 13–17.6 μ broad. The filaments in the alga have been recorded as 19–21 μ broad.

### 65. **Lyngbya subconfervoides** Borge

Die von Dr. Loefgren in Sao Paulo gesammette Süsswasseralgen, Ark. f. Bot. 15(13): 91, pl. 7, fig. 6, 1918; Geitler, Kryptogamenflora, 1067, fig. 681, 1932.

Thallus thin, woolly, dull blue filaments long, straight, 21–30 μ broad; sheath colourless, 3 μ thick, when old indistinctly lamellated, not coloured violet by chlor-zinc-iodide; trichome not constricted at the cross-walls, cross-walls not granulated, blue-green, 18–27 μ broad, not attenuated at the ends; cells 1/2–1/3 as long as broad; end cell rounded, without calyptra.

In the straggling community of the River Hooghly, Calcutta (Biswas, 1942, 196).

## SPECIES INQUIRENDA

### **Lyngbya loriae** Forti

in De Toni, Sylloge Algarum, 5: 286, 1907.

Thallus expanded, dirty olive-green; filaments densely arranged, intricate; sheath close, colourless; cells 2.5-3.7 μ broad, longer than broad.

Forming a stratum on mud in running water near Jatinda, India (Carter, 1926, 267).

The filaments in the Indian alga were 2.5–3.5 μ, trichomes 1.8–2.5 μ broad, and cells, 2.5–5 μ long.

## SPECIES INCERTA SEDIS

*vel non sufficienter cognita*

1. *L. crispa* Ag. (Prain, Rec. bot. Surv. India, 3: 333, 1905; Biswas, J. Dept. Sci., Calcutta Univ., 8: 23, 1926) from salt lakes, Calcutta.

2. *L. crispa* Ag. var. *violacea* Kütz. — In salt lakes, Sealdah, Calcutta and Dalkissar river between Ranigungee and Barcoor, Bengal (Martens and Krempelhuber, 1869, 234).

## SPECIES EXCLUDENDA

*L. iyengari* Mitra (1951, 359/362) *nomen nudum.*

*L. iyengari* var. *violacea* Mitra (1951, 359/362) *nomen nudum.*

## SCHIZOTHRIX Kütz.

Phyc. gene., 230, 1843; Gomont, Monogr. Oscillariées, 292, 1892.

Trichome generally many, seldom single, in large soft to firm thallus, enclosed in a thin or thick sheath, often each trichome with its own sheath; sheath colourless to yellow-brown, red or seldom violet or blue in colour, its ends often pointed; filaments densely packed, forming a leathery stratum, occasionally only a trichome and sparsely branched, forming tuft-like growth or in erect bundles, which are more or less branched; thallus attached, seldom free-swimming.

Type species: *Schizothrix fuscescens* Kützing.

## KEY TO THE SUBGENERA

1. Filaments generally in erect bundles .................... 2
1. Filaments generally not in erect bundles .................... 3
  2. Sheath colourless .................... *Symplocastrum* (p. 322)
  2. Sheath coloured .................... *Chromosiphon* (p. 323)
3. Sheath hyaline .................... 4
3. Sheath coloured, filaments single, or in erect or felted thallus.. *Chromosiphon* (p. 323)
  4. Filaments entangled forming a membranous thallus .. *Hyphaeothrix* (p. 322)
  4. Filaments pulvinate in caespitose or hemispherical colonies, branched, attached or free swimming, seldom in the mucilage of other algae, incrusted with calcium carbonate .................... *Inactis* (p. 322)

## KEY TO THE SPECIES

### Subgenus *Inactis* Thuret

1. Thallus in cushion like hemispherical colonies, with calcium incrustation .......... 2
1. Thallus without calcium incrustation, not in cushion like hemispherical colonies.... 3
  2. Cells quadrate or longer than broad .................... 1. *Sch. pulvinata* (p. 323)
  2. Cells shorter than broad .................... 5. *Sch. vaginata* (p. 325)
3. Filaments attached, ascending .................... 4
3. Filaments not attached .................... 5
  4. Trichome 6 μ broad .................... 2. *Sch. mexicana* (p. 323)
  4. Trichome 2.7–5 μ broad .................... 3. *Sch. penicillata* (p. 323)
5. Trichomes 0.9–1.5 μ broad .................... 4. *Sch. lacustris* (p 325)
5. Trichomes 2–3 μ broad .................... 5. *Sch. vaginata* (p. 325)

### Subgenus *Hyphaeothrix* Gomont

1. Thallus with calcium incrustation .................... 6. *Sch. lateritia* (p. 326)
1. Thallus without calcium incrustation .................... 2
  2. End cell rounded .................... 3
  2. End cell conical .................... 4
3. Trichomes 3–4 μ broad .................... 7. *Sch. porphyromelana* (p. 326)
3. Trichomes 1.5–2 μ broad .................... 8. *Sch. lardacea* (p. 327)
  4. Trichome 1.5–3 μ broad; cells 2–3 times as long as broad 9. *Sch. arenaria* (p. 327)
  4. Trichome 0.6–0.8 μ broad; cells 6–8 times as long as broad 10. *Sch. delicatissima* (p. 327)

### Subgenus *Symplocastrum* Gomont

1. Cells shorter than broad, 1.4–2 μ broad .................... 11. *Sch. fragilis* (p. 328)
1. Cells longer than broad .................... 2
  2. Trichomes 3–6 μ broad .................... 12. *Sch. friesii* (p. 328)
  2. Trichomes 0.8–1.5 μ broad .................... 13. *Sch. tenuis* (p. 329)

### Subgenus *Chromosiphon* Gomont

1. Cells shorter than broad .......................................... 2
1. Cells mostly longer than broad .......................................... 4
2. Sheath purple .......................... 14. *Sch. purpurascens* (p. 329)
2. Sheath golden yellow or yellowish to brownish .......................... 3
3. Trichome 6–7.5 μ broad, cells very short .............. 15. *Sch. beccarii* (p. 329)
3. Trichome 7–13 μ broad, cells 4–9 μ broad .............. 16. *Sch. muelleri* (p. 330)
4. Sheath reddish .......................... 17. *Sch. telephoroides* (p. 330)
4. Sheath yellowish to brownish .......................................... 5
5. Trichome 2–3 μ broad.......................................... 6
5. Trichomes 3–6 μ broad, cells up to 2½ as long as broad....... 18. *Sch. lamyi* (p. 330)
6. End cell rounded, cells very long .............. 19. *Sch. fuscescens* (p. 332)
6. End cells conical, cells longer than broad ...... 20. *Sch. ericetorum* (p. 332)

### 1. **Schizothrix pulvinata** (Kütz.) Gomont

Monogr. Oscillariées, 298, 1892; Geitler, Kryptogamenflora, 1088, 1932.

Thallus cushion-shaped or crustaceous, outside warted, inside zonated, prominently incrusted with calcium and more or less hardened, blue-green, filaments arranged parallel, more or less straight, closely arranged, sparsely branched, with adpressed branches; sheath colourless, pointed at the ends coloured violet by chlor-zinc-iodide, with many trichomes in each sheath; trichomes constricted at the cross-walls, 1–2 μ broad; cells quadrate or up to 2 times longer than broad, blue-green; end cells rounded.

On the walls along the lime courses, Berkuda island, Chilka lake (Biswas, 1924, 363).

### 2. **Schizothrix mexicana** Gomont

Monogr. Oscillariées, 304, 1892, Geitler, Kryptogamenflora, 1094, 1932.

Filaments forming a blackish violet ascending penicillate tufts; unbranched below, above branched, false-branches adpressed; sheath very thin, not lamellated, somewhat uneven, coloured violet by chlor-zinc-iodide, in the basal part with many trichomes twisted like a rope; trichomes constricted at the cross-walls, 6 μ broad; cells 1–1/3 times as long as broad, 2–5 μ long; end cell not attenuated, rotund.

Sides of water reservoir, Saharanpur Dist. (Randhawa, 1936a. 402/405; 1936c, 42).

### 3. **Schizothrix penicillata** (Kütz.) Gomont

Monogr. Oscillariées, 305, pl. 7, figs. 8–10, 1892; Frémy, Myxo. d'Afr. équat. franc., 99, fig. 94, 1929; Geitler, Kryptogamenflora, 1096, fig. 702, 1932.

Thallus soft, in penicillate tufts, dark green, ascending; filaments unbranched or sparsely branched; sheath colourless, not lamellated, in the basal part thick or uneven, with two to many trichomes, above thin and mostly with

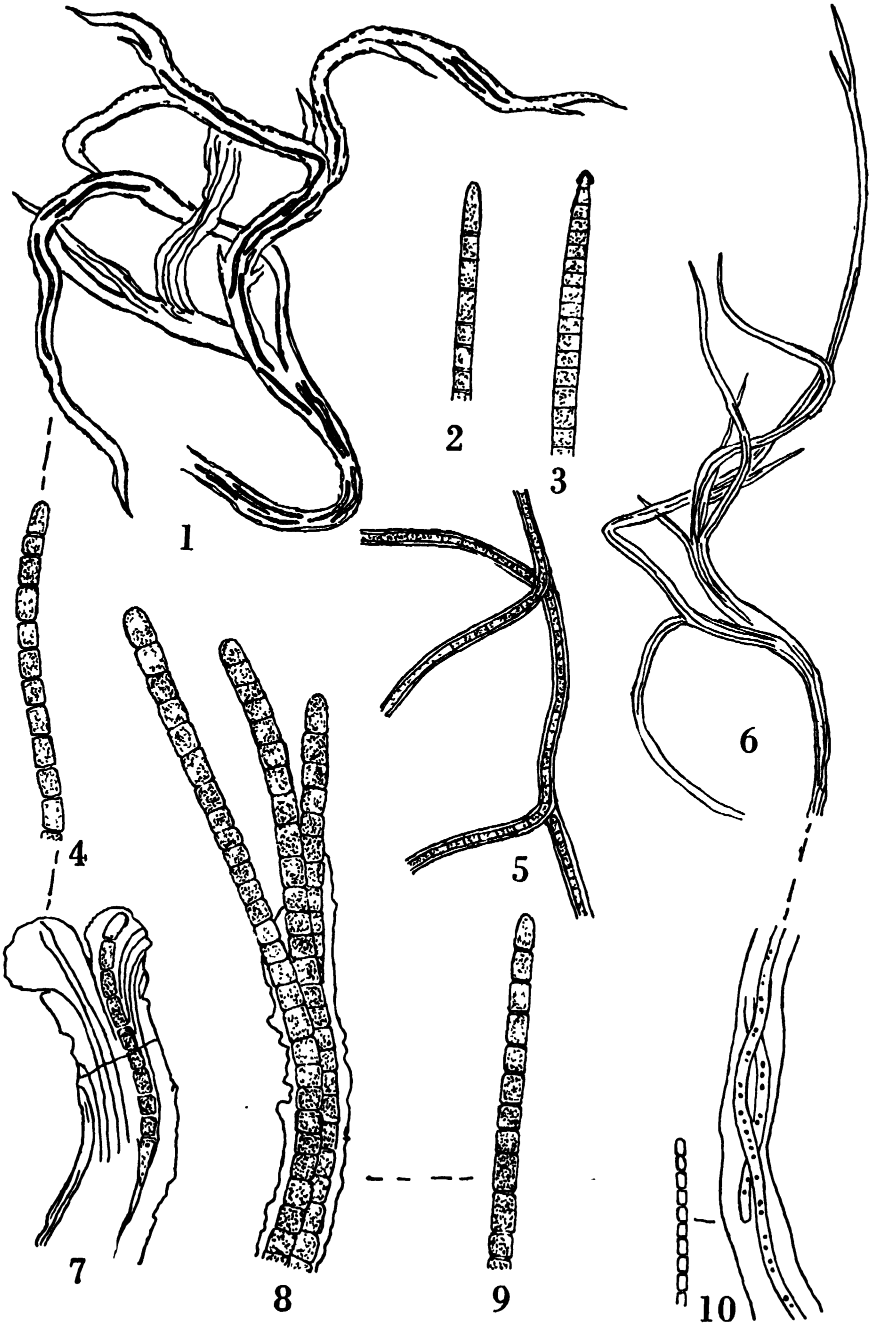

PLATE 56, Figs. 1–10.

1, 4, 7. *Schizothrix lamyi* Gom. (after Gomont); 2. *Microcoleus paludosus* (Kütz.) Gom. (after Gomont); 3. *M. vaginatus* (Vauch.) Gom. (after Gomont); 5. *Plectonema dangeardii* Frémy (after Frémy); 6, 10. *Schizothrix lacustris* A. Br. (after Gomont); 8, 9. *Microcoleus subtorulosus* (Bréb.) Gom. (after Gomont).

only a single trichome, not coloured violet by chlor-zinc-iodide, in the lower part with many spirally coiled and in the upper part only with a fewer trichomes; trichomes not distinctly constricted at the cross-walls, 2.7–5 μ broad, more or less violet; cells a little shorter to twice as long as broad, 2–9 μ long; end cell obtuse conical.

On shells of *Thaia Intha*, Inle lake (Biswas, 1936, 122) ( ? )

Biswas (*loc. cit.*) has described a variety, (var. *tripunctata*), of *L. penicillata* (Kütz.) Rabenh. Gomont (1892) has transferred Kützing's species (*Leibleinia penicillata* Kütz., = *Lyngbya penicillata* (Kütz.) Rabenh.) to *Schizothrix*. An examination of Biswas's material is necessary to decide its identity.

### 4. **Schizothrix lacustris** A. Br. ex Gomont

A. Braun in Kützing, Species Algarum, 320, 1849; Gomont, Monogr. Oscillariées, 301, pl. 6, figs. 9–12, 1892; Frémy, Myxo. d'Afr. équat. franc., 96, fig. 92, 1929; Geitler, Kryptogamenflora, 1092, figs. 698, 699, 1932; Frémy, Cyano. cotes d'Eur., 77, pl. 20, fig. 4, 1933.

Pl. 56, Figs. 6, 10

Thallus cushion-shaped, or crustaceous, often free-floating, without or with only a little calcium incrustation; filaments aggregated, at the ends richly branched; sheath thick, colourless or yellow, coloured violet by chlor-zinc-iodide; trichome many in a common sheath, in the older parts of the filaments and often spirally coiled, in the younger parts single, or a few together, constricted at the cross-walls (in herbarium specimens), 1–1.5 μ broad; cells longer than broad, up to 4 μ long.

On rocks and pebble in the beds of Kalijhora stream, Assam (Biswas, 1936, 123); in a tank at Bandra, Bombay (Gonzalves and Joshi, 1946, 176).

Desikachary and Ramakrishnan (1953) have reported the formation of aegagrophilous balls by the species, in a lake at Chingleput near Madras.

### 5. **Schizothrix vaginata** (Näg.) Gomont

Monogr. Oscillariées, 302, pl. 7, figs. 1–4, 1892; Frémy, Myxo. d'Afr. équat. franc., 96, fig. 93, 1929; Geitler, Kryptogamenflora, 1089, fig. 696, 1932; Frémy, Cyano. cotes d'Eur., 77, pl. 19, fig. 5, 1933.

Pl. 58, Figs. 9–11

Thallus expanding, crustaceous, warty, with or without calcium incrustation, greyish brown or dark blackish green; filaments straight, arranged more or less erect and parallel, or entangled with one another, branched at the tips; sheath thick, sometimes lamellated, acuminate at the ends, or seldom funnel-shaped, coloured violet by chlor-zinc-iodide, with few trichomes or with only one; trichomes granulated at the cross-walls, not constricted, 2–3 μ broad; cells mostly shorter than broad, 1–2 μ long; end cells rounded.

Type not recorded.

Geitler (1932) gives India as one of the localities under *S. vaginata.*

### Var. **non-granulata** Ghose

On a collection of Myxophyceae from Mergui and some neighbouring islands, J. Burma Res. Soc., 17(3): 250, pl. 3, fig. 13, 1927c.

Pl. 58, Figs. 3, 4

Thallus expanded, crustaceo-gelatinous, not incrusted with chalk; filaments more or less parallel, or floccuous, branched at the end; sheath thick, lamellated, usually attenuated at the apex, with a few trichomes; trichomes 13–15 μ thick, slightly constricted at the joints, not granulated at the cross-walls, cells mostly shorter than broad; apex slightly attenuated, nearly rounded, calyptra absent.

On the *Hevea brasiliensis* Kamaw, Kisseraing island and among mosses on various trees, Madaw islands (Ghose, *loc. cit.*).

### 6. **Schizothrix lateritia** (Kütz.) Gomont

Monogr. Oscillariées, 308, pl. 8, fig. 4, 1892; Geitler, Kryptogamenflora, 1081, fig. 691, 1932.

Thallus membranaceous or leathery, sometimes spreading up to 1 sq. meter, or cushion-shaped, up to 2 mm thick, with calcium incrustation, grey to flesh red, inside colourless; filaments mostly thickly packed, more or less branched; sheath thin, or broad, colourless, uneven on the outside, pointed at the ends, not or very lightly coloured violet by chlor-zinc-iodide, with many trichomes; cells 1.3–1.6 μ broad, 2–5 (–9) μ long, often granulated at the cross-walls; end cells rounded.

India (Hansgirg ex De Toni, 1907, 333); on bricks, Rangoon (Skuja, 1949, 56).

Schmidle (1900b, 186) has described *Hyphaeothrix lateritia* f. *lyngbyacea* Schmidle from among other algae in a water reservoir at Poona.

### 7. **Schizothrix porphyromelana** (Bruhl et Biswas) Geitler

in Pascher's Süsswasserflora, 12: 449, 1925; Kryptogamenflora, 1083, 1932.

= *Hyphaeothrix porphyromelana* Bruhl and Biswas, Algae of Bengal filter-beds, J. Depat. Sci., Calcutta Univ., 4 (Bot.): 8, 1922a.

Thallus expanded, more or less membranaceous, leathery, not incrusted with calcium, about 1 mm size, blackish; filaments long, bent, dull blue to blackish purple, often densely arranged; sheath thin, colourless; cells, 3–4 μ broad, not constricted at the cross-walls, about 2 μ long.

Filter beds, Faridpur, Bengal (Bruhl and Biswas, *loc. cit.*).

### 8. **Schizothrix lardacea** (Ces.) Gomont

Monogr. Oscillariées, 311, pl. 8, figs. 8 and 9, 1892; Frémy, Myxo. d'Afr. équat. franc., 92, fig. 89, 1929; Geitler, Kryptogamenflora, 1085, figs. 693a, b, 1932; Frémy, Cyano. cotes d'Eur., 78, pl. 20, fig. 3, 1933.

Thallus expanding, not calcium incrusted, up to 3 cm thick, firm, elastic, lamellated, very sparsely branched; sheath colourless, firm, pointed at the ends, at first thin, later thick, even on the outside, coloured violet by chlor-zinc-iodide, with one or a few trichomes; trichomes not constricted at the cross-walls, cross-walls often granulated, 2 granules, 1.5–2 μ broad; cells quadratic or slightly less longer than broad, 2–3 μ long, blue-green; end cell obtuse.

On paddyfields, Hanaratgodha, Ceylon (West and West, 1902, 203); Shembaganur (Frémy, 1942, 21); Rangoon in Burma (Skuja, 1949, 56).

### 9. **Schizothrix arenaria** (Berk.) Gomont

Monogr. Oscillariées, 312, pl. 8, figs. 11 and 12, 1892; Geitler, Kryptogamenflora, 1085, fig. 693d-e, 1932.

inkl. var. *non-constricta* Ghose, The Myxophyceae of Rangoon II, J. Burma Res. Soc., 16 (3) : 222, 1927a.

Thallus thin, not incrusted with calcium; filaments densely grouped, with branching at the tips, branches much contorted; sheath firm, at the ends pointed, outside even, in the lower portions thick and lamellated, coloured violet by chlor-zinc-iodide, with a few trichomes; trichome constricted at the cross-walls or unconstricted, 1.5–3 μ broad, cells up to 5 μ long; end cell pointed and conical.

On wet sandy soil, Rangoon (Ghose, 1927c, 81); in cultures of paddy-field soil from Thana, Goregaon and Dahisar in Bombay state (Gonzalves and Gangla, 1949, 54).

Ghose (1927a; also *see* Banerji, 1938, 106) describes from Rangoon var. *non-constricta* which is very similar in habit to the above species. Geitler (1932, p. 1086) has included it here (Pl. 59, fig. 12).

### 10. **Schizothrix delicatissima** West et West

J. Bot., Lond., 35: 269, 1897; Frémy, Myxo. d'Afr. équat. franc., 92, 1929; Geitler, Kryptogamenflora, 1086, 1932.

Filaments 100–400 μ long, bent, sparsely branched, 5–6.5 μ broad; sheath colourless, uneven on the outside, at the ends long acuminate, seldom slightly rounded with 1–2 trichomes; trichomes constricted at the cross-walls, 0.6–0.8 μ broad; cells 6–8 times as long as broad, bright blue-green; end cells pointed and conical.

Among *Stigonema panniforme* on summit of Hakgala rock, Ceylon (West and West, *loc. cit.*); in cultures of paddyfield soil from Thana near Bombay (Gonzalves and Gangla, 1949, 54).

### 11. **Schizothrix fragilis** (Kütz.) Gomont

Monogr. Oscillariées, 314, pl. 8, figs. 13, 14, 1892; Geitler, Kryptogamenflora, 1074, fig. 682, 1932.

= *Leptothrix muralis* Kütz., Phyc. gene., 199, 1843, *non* Rabenh.

= *Hyphaeothrix calcicola* Ag. f. *muralis* Rabenh., Fl. Eur. Alg., 2: 78, 1865.

Thallus up to 1 mm high, filzing, olive green or blue-green; filaments more or less bent, parallel forming short, erect bundles or tufts; sheath more or less gelatinizing, colourless, uneven on the outside, coloured violet by chlor-zinc-iodide, many trichomes in each sheath; trichomes constricted at the cross-walls, 1.4–2.5 μ broad; cells nearly quadratic or somewhat shorter than broad, 1–2 μ long, blue-green.

On damp walls, Rajmahal in Bengal (Martens, 171); Henzadah in Burma (Zeller 1873b, 176; Theobald, 1883, 24).

### 12. **Schizothrix friesii** (Ag.) Gomont

Monogr. Oscillariées, 316, pl. 9, figs. 1, 2, 1892; Frémy, Myxo. d'Afr. équat. franc., 103, fig. 97, 1929; Geitler, Kryptogamenflora, 1076, figs. 685 and 686, 1932.

Pl. 57, Figs. 1, 6

Thallus blackish or greenish steel blue; filaments in lower parts contorted, above rarely straight, parallel; fascicles rigid, erect, pointed up to 3 cm high; sheath colourless, lamellated, acuminate at the ends, coloured violet by chlor-zinc-iodide, with few trichomes or single trichome; trichomes distinctly constricted at the cross-walls, 3–6 μ broad; cells nearly quadratic, or up to 2 times as long as broad, 4–11 μ long, blue-green; end cell obtuse, conical.

In the environs of Shembaganur (Frémy, 1942, 21).

### f. **repens** Frémy

Cyanophycées de l'Indes Meridionale, Blumea, suppl. 2: 22, 1942.

Stratum expanded, blackish, filaments united in fascicles which are not erect, but creeping; trichomes as in type.

On moist soil, near Shembaganur (Frémy, *loc. cit.*).

### 13. **Schizothrix tenuis** Woronich.

Not. Syst. Inst. Crypt. Horti Bot. Petropol., 2: 98, 1923; Geitler, Kryptogamenflora, 1078, 1932.

Filaments up to 3 mm long, and forming 30–50 μ thick bundles, contorted, 2–4 μ broad; trichomes 0.8–1.5 μ broad, not constricted at the cross-walls; cells cylindrical, sheath coloured violet by chlor-zinc-iodide.

In laboratory cultures of paddy-field soil, Khandala near Bombay (Gonzalves and Gangla, 1949, 54).

### 14. **Schizothrix purpurascens** (Kütz.) Gomont

Monogr. Oscillariées, 320, pl. 9, figs. 6–8, 1892; Frémy, Myxo. d'Afr. équat. franc., 117, fig. 106, 1929; Geitler, Kryptogamenflora, 1103, fig. 709, 1932.

Pl. 57, Figs. 3–5

Thallus expanding, dark red or violet; filaments sub-dichotomously false branched, arranged in more or less parallel, coiled to form creeping tufts; sheath rose to purple red or reddish orange, at the ends pointed and colourless, thick, distinctly lamellated, outside uneven, with large number of trichomes in each sheath, coloured violet by chlor-zinc-iodide; trichomes constricted at the cross-walls or unconstricted, 6–8 μ broad; cells 3–8 μ long, blue-green; end cell conical often pointed.

Shembaganur (Frémy, 1927, 46/47) ( ? ).

The type has not been reported. But Frémy (1927, 46/47) has recorded var. *cruenta* Gom. Gomont differentiates two varieties based on the colour of the trichome and whether it is constricted or unconstricted. Geitler (1932) does not retain var. *cruenta* Gom. distinct.

### 15. **Schizothrix beccarii** Gomont

Monogr. Oscillariées, 323, pl. 10, figs. 8, 9, 1892; Frémy, Myxo. d'Afr. équat. franc., 112, fig. 102, 1929; Geitler, Kryptogamenflora, 1110, figs. 708a, b, 1932.

Thallus woolly tufts, yellowish, up to 5 mm thick; filaments long, intricate, tortuous, unbranched or branched in the upper part; sheath colourless or when old yellowish brown, firm, thin, cylindrical, coloured blue with chlor-zinc-iodide; trichome blue-green, in the basal parts many in each sheath and often congested, in the upper part one in each sheath, constricted at the cross-walls, 6–7.5 μ broad; cells up to 1/3 as long as broad, 2–6 μ long; end cells rounded.

Attached to stones in a shallow stream, receiving dirty water near the road leading to Spreadeagle falls, Shillong in Assam (Parukutty, 1939, 235).

16. **Schizothrix muelleri** Näg. ex Gomont

Nägeli in Kützing, Species Algarum, 320, 1849; Gomont, Monogr. Oscillariées, 321, pl. 10, figs. 5–7, 1892; Geitler, Kryptogamenflora, 1110, figs. 7–15, 1932.

= *Hormosiphon cylindraceus* Zanard., Phyc. ind. pugillus, 30, 1872.

Pl. 57, Figs. 9, 10

Thallus expanding, brown to blackish green; filaments arranged in creeping bundles or free-floating tufts; sheath golden yellow, firm or somewhat gelatinizing, lamellated, uneven, at the ends pointed, coloured violet by chlor-zinc-iodide, with a few sometimes only one trichome; trichome slightly constricted at the cross-walls, 7–13 μ broad; cells 4–9 μ long, blue-green; end cell obtuse.

On mosses, Newara Elliya, in Ceylon (Zanardini, 1872, 153); Matheran, Bombay (Schmidle, 1900b, 161).

f. **lyngbyoidea** Gomont

In the environs of Shembaganur, Madras State (Frémy, 1942, 21).

17. **Schizothrix telephoroides** (Mont.) Gomont

Monogr. Oscillariées, 319, pl. 10, figs. 1–4, 1892; Frémy, Myxo. d'Afr. équat. franc. 116, fig. 105, 1929; Geitler, Kryptogamenflora, 1101, fig. 707, 1932.

Pl. 57, Figs. 2, 7, 8

Thallus caespitose or crustaceous, reddish; filaments nearly dichotomously branched forming tufts, up to 5 cm long; sheath very thick, firm, lamellated, inside red, outside colourless, somewhat uneven, coloured violet by chlor-zinc-iodide, commonly with one trichome, sometimes two trichomes in each sheath; trichomes distinctly constricted at the cross-walls, 4–9 μ broad; cells 1–2 times as long as broad, 6–14 μ long, blue-green; end cell not attenuated, rounded.

On soil, Ceylon (Gomont, 1892, p. 319) and in a valley at Cherrapunji in Assam (Biswas, 1934, 14).

18. **Schizothrix lamyi** Gomont

in Bornet, Algues du départment de la Haute-Vienne etc., Bull. Soc. bot., Fr., 38: 250, 1891; Monogr. Oscillariées, 323, pl. 11, figs. 1–3, 1892; Frémy, Myxo. d'Afr. équat. franc., 110, fig. 101, 1929; Geitler, Kryptogamenflora, 1114, fig. 720, 1932.

Pl. 56, Figs. 1, 4

Thallus greenish brown; filaments prominently bent, richly branched, with branches spread out; sheath golden yellow, firm, prominently lamellated,

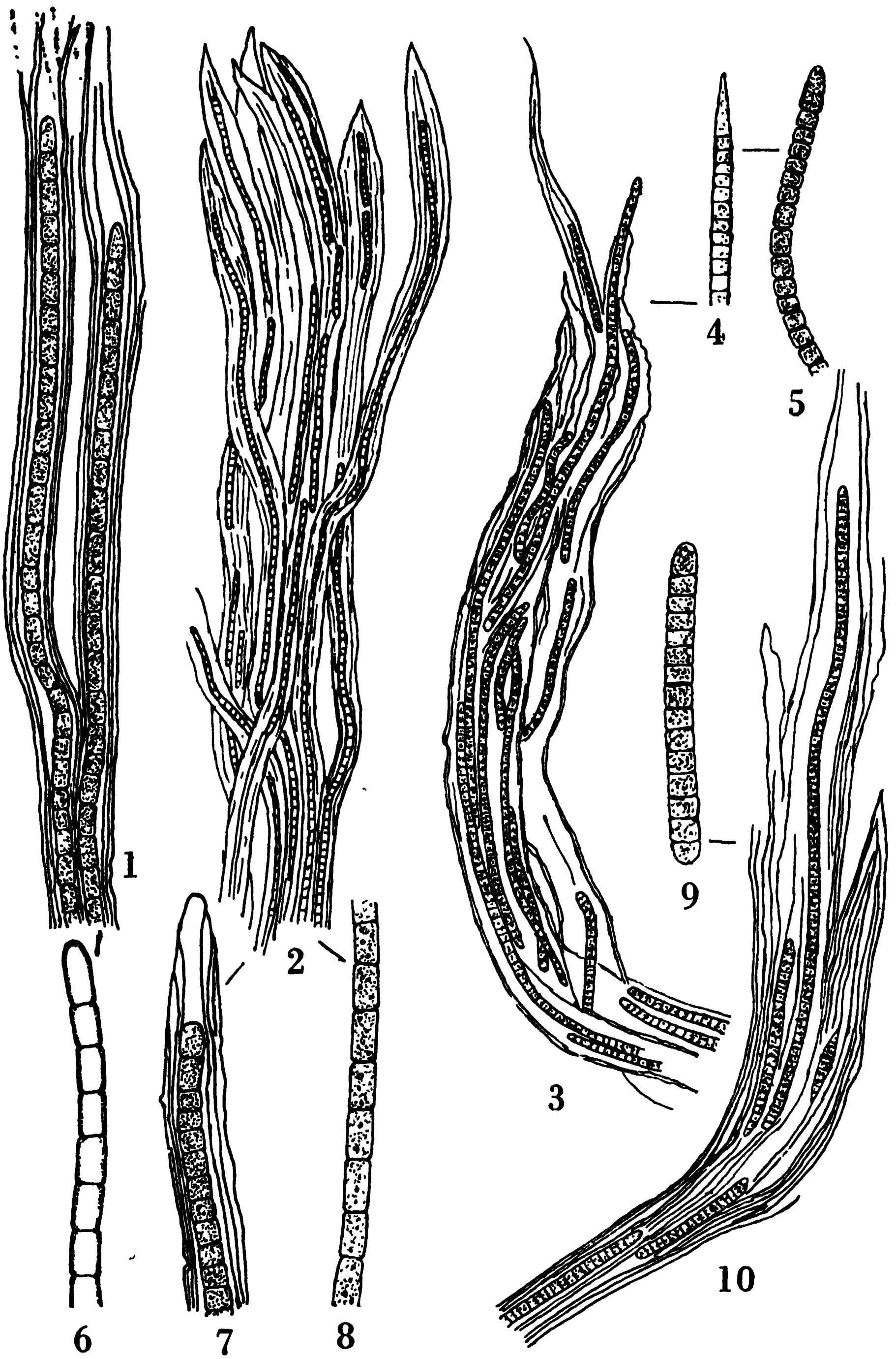

PLATE 57, Figs. 1–10.

1, 6. *Schizothrix friesii* (Ag.) Gom. (after Gomont); 2, 7, 8. *Sch. telephoroides* (Mont.) Gom. (after Gomont); 3–5. *Sch. purpurascens* (Kütz.) Gom. (after Gomont); 9, 10. *Sch. muelleri* Nag. (after Gomont).

outside uneven, pointed at the ends or funnel-shaped, coloured violet by chlor-zinc-iodide, with a few or a single trichome in each sheath; trichomes slightly constricted at the cross-walls, 3–4 μ broad; cells mostly longer than broad, 4–8 μ long, blue-green; end cell conical, rounded.

Panchgani in Bombay State (Schmidle, 1900b, 161) and Shembaganur in Madras State (Frémy, 1942, 21).

### 19. **Schizothrix fuscescens** Kützing ex Gomont

Kützing, Phyc. gene., 230, 1843; Gomont, Monogr. Oscillariées, 324, pl. 11, figs. 4–6, 1892; Frémy, Myxo. d'Afr. équat. franc., 104, fig. 99, 1929; Geitler, Kryptogamenflora, 1112, fig. 717, 1932.

Pl. 58, Figs. 7, 8

Thallus thin dull brown to yellowish; filament very much coiled, richly branched; branches closely adpressed; sheath lamellated, yellowish brown or golden yellow, inside and colourless outside, at the ends long pointed, outside mostly uneven, coloured violet by chlor-zinc-iodide; mostly only with two trichomes; trichomes constricted at the cross-walls, 2–3 μ broad; cells 8–13 μ long, blue-green; end cell rounded.

On moist rocks near Bangalore ( ! ).

The trichomes in the Bangalore alga are 1.3–3.9 μ broad and the cells are 2.6–8 μ long.

### 20. **Schizothrix ericetorum** Lemmermann

Kryptogamenflora der Mark Brandenburg, 3: 153, fig. 10, n. p. 102, 1910; Geitler, Kryptogamenflora, 1113, fig. 718, 1932.

Pl. 58, Figs. 5, 6

Thallus dark brown, leathery; filaments many together, richly branched; sheath yellowish brown, firm, distinctly lamellated, pointed at the ends, not coloured violet by chlor-zinc-iodide, many trichomes inside; trichomes not constricted at the cross-walls, 2–2.7 μ broad; cells nearly quadrate or longer than broad, 3–5.5 μ long, pale blue-green; end cells pointed, conical.

On moist walls near road cutting, Tenmalai ( ! ).

## SPECIES INQUIRENDAE

### **Schizothrix subundulata** (Martens) comb. nov.

= *Hyphaeothrix subundulata* Martens, Proc. Asiatic Soc. Bengal, 40: 71, 1871.—In tanks on *Paludine* shells, Rajmahal, Bengal (Martens *loc. cit.*).

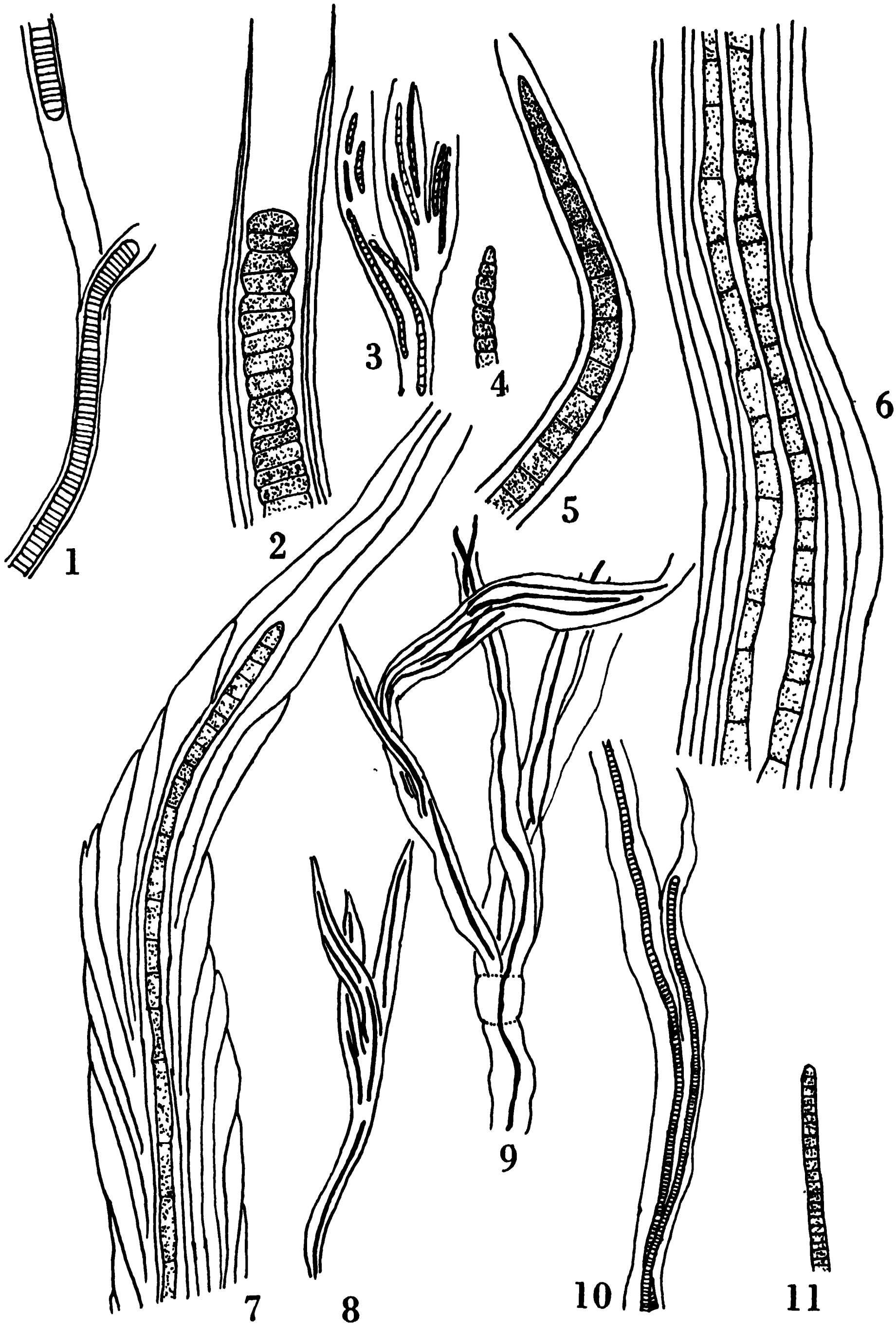

PLATE 58, Figs. 1–11.

1, 2. *Plectonema tomasinianum* (Kütz.) Born. v. *vandalurense* var. nov. (Orig.); 3, 4. *Schizothrix vaginata* var. *nongranulata* Ghose (after Ghose); 5, 6. *Sch. ericetorum* Lemm. (Orig.); 7, 8. *Sch. fuscescens* Kütz. (Orig.); 9–11. *Sch. vaginata* (Näg.) Gom. (after Gomont).

### **Schizothrix viridula** (Zeller) comb. nov.

= *Hyphaeothrix viridula* Zeller, Hedwigia, 12: 169, 1873b.—Marsh at Wanet, Pegu, Burma (Zeller, 1873b, 169; 1873a, 177; Theobald, 1883, 24).

### **Schizothrix tenax** (Wolle) comb. nov.

= *Leptothrix tenax* Wolle, F. W. Algae of U.S., 319, pl. 208, fig. 2, 1887.

= *Hyphaeothrix tenax* Wolle, F. W. Algae, Bull. Torrey bot. cl., 6: 282, 1878; Forti in De Toni, Sylloge Algarum, 5: 329, 1907.—Salt lakes, Calcutta (Prain, 1903, 333; Biswas, 1926, 23).

### **Schizothrix confervae** (Kütz.) comb. nov.

= *Hyphaeothrix confervae* Kütz., Phyc. gene. 230, 1843; Forti in De Toni, Sylloge Algarum, 5: 328, 1907.—Ceylon (Ferguson ex Murray, 1887, 44).

### **Schizothrix aeruginea** (Rabenh.) comb. nov.

= *Hyphaeothrix aeruginea* Rabenh.—On soil, Phoungyee in Burma (Zeller, 1873b, 176).

### Var. **subtorulosa** (Zeller) comb. nov.

= *H. aeruginea* Rabh. var. *subtorulosa* Zeller, Asiatic Soc., Bengal, 42 (2): 176, 1873b.—In a spring at Kynbali-choung, Pegu in Burma (Zeller, 1873b, 176; Theobald, 1883, 24).

## SYMPLOCA Kützing

Phyc. gene., 201, 1843; Gomont, Monogr. Oscillariées, 104, 1892.

Trichome single in a thin sheath; filaments at first prostrate, later mostly forming erect bundles, partly false branched; sheath firm or later gelatinising; trichome straight, sometimes slightly attenuated; end cell not capitate, sometimes with a thickened outer membrane.

Lectotype: *S. muralis* Kütz.

Four species of the original seven included by Kützing are still retained in the genus. No type has been designated by Kützing. According to Setchell and Gardner (1919, 80), *S. muralis* should be considered as the type.

### KEY TO THE SPECIES

1. Plants halophilous .................................................. 2
1. Plants terrestrial, hydrophilous or thermal .................................. 3
    2. Trichomes 6–8 μ broad ........................ 1. *S. hydnoides* (p. 335)
    2. Trichomes 1.5–3.5 μ broad .................... 2. *S. laete-viridis* (p. 335)

3. Trichomes 3 μ broad or broader .................................................. 4
3. Trichomes narrower................................................................... 6
    4. Cells longer than broad, 5–8 μ broad .............. 3. *S. muscorum* (p. 337)
    4. Cells as long as or shorter than broad ................................... 5
5. Trichome 3.4–4 μ broad .................................. 4. *S. muralis* (p. 337)
5. Trichome 4.5 μ broad ..................................... 5. *S. flaccida* (p. 338)
    6. Bundles anastomosing.......................................................... 7
    6. Bundles not anastomosing ................................................... 8
7. Trichomes 1.3–2 μ broad, slightly constricted, fascicles caespitose, blue-green 6. *S. elegans* (p. 338)
7. Trichomes 1.8–3 μ broad, unconstricted, thallus yellowish gray 7. *S. parietina* (p. 339)
    8. Trichomes 1.2–2 μ broad, constricted, not coloured by chlor-zinc-iodide 8. *S. thermalis* (p. 339)
    8. Trichomes 2–3 μ broad, not torulose, coloured by chlor-zinc-iodide 9. *S. cartilaginea* (p. 339)

### 1. **Symploca hydnoides** Kützing ex Gomont

Kützing, Species Algarum, 272, 1849; Gomont, Monogr. Oscillariées, 106, pl. 2, figs. 1–4, 1892; Forti in De Toni, Sylloge Algarum, 5: 300, 1907; Geitler, Kryptogamenflora, 1119, fig. 724, 1932; Frémy, Cyano. cotes d'Eur., 81, pl. 21, fig. 3, 1923.

Pl. 60, Figs. 2, 3, 6

Thallus bundles or tufts; dirty to dark violet, bundles up to 3 cm long, erect, pointed at the base; sheath often colourless; filaments very densely aggregated, slightly united, partly branched irregularly bent; sheath thin, less slimy, coloured indistinctly violet by chlor-zinc-iodide; trichome blue-green, 6–14 μ broad, often constricted at the cross-walls in the apical portion; cells as long as or twice as broad, 5–14 μ long; end cell slightly swollen, without calyptra.

Indian ocean near Ceylon (Ferguson in Gomont, 1892, 166) and Galle, Ceylon (Boergeson, 1936, 54); Salt lakes, Calcutta (Biswas, 1926, 24).

### f. **minor** Iyengar and Desikachary

J. Madras Univ., B, 16: 64, fig. 30, 1944.

Filaments forming dark blue-green fascicles, up to one inch high; false branching present, filaments 5.2–6.6 μ broad; sheath, thin, hyaline, and homogeneous; trichome blue-green, 2.6–3.9 μ broad, usually not granulated at the cross-walls; cells shorter or longer than broad, up to twice as long as broad; apical cell rounded, without calyptra (Pl. 49, fig. 13).

On submerged rocks, Krusadai islands (Iyengar and Desikachary, *loc. cit.*).

### 2. **Symploca laete-viridis** Gomont

Monogr. Oscillariées, 109, pl. 2, figs. 6–8, 1892; Forti in De Toni, Sylloge Algarum, 5: 302, 1907; Geitler, Kryptogamenflora, 1121, fig. 728, 1932.

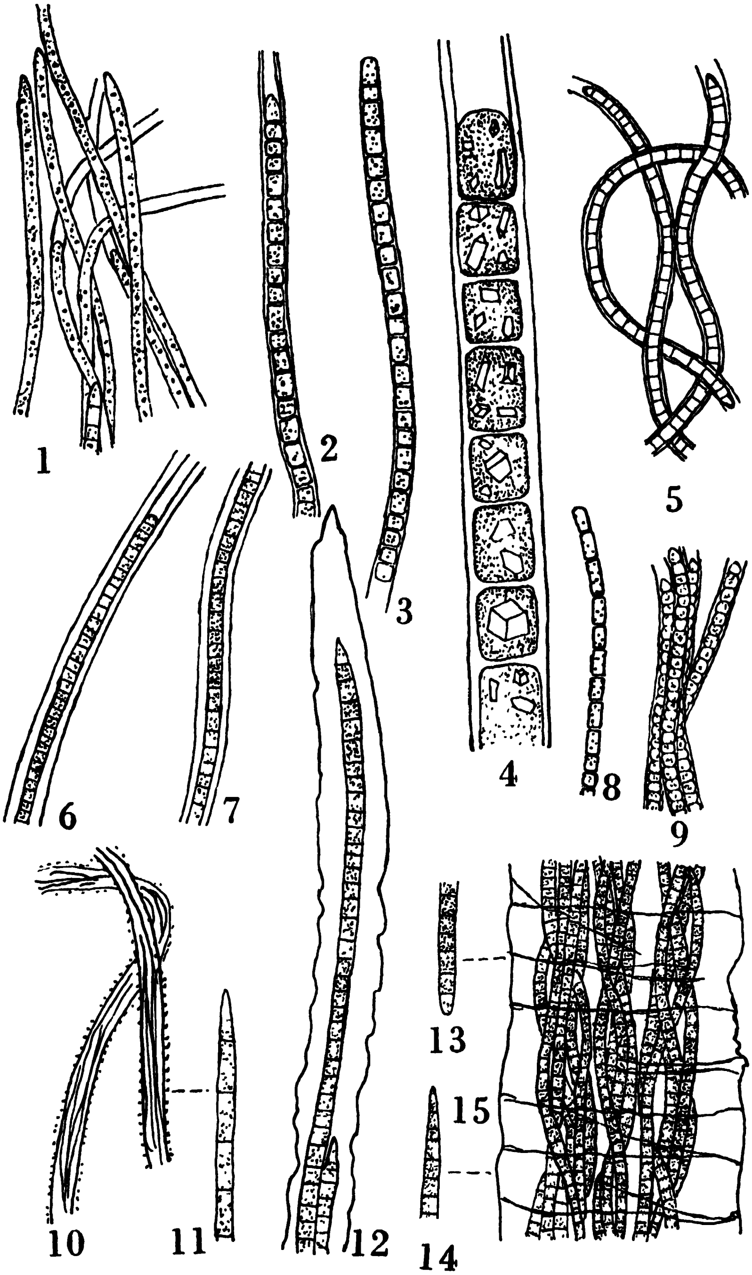

PLATE 59, Figs. 1–15.

1, 2. *Symploca cartilaginea* (Mont.) Gom. (after Gomont); 3, 4. *S. muscorum* (Ag.) Gom. (3 after Gomont, 4 after Elenkin & Danilov); 5. *S. muralis* v. *minor* Gardner (after Gardner); 6, 7. *Phormidium muscosum* v. *arvense* Rao, C. B. (after Rao); 8. *P. molle* (Kütz.) Gom. (after Gomont); 9. *P. truncicola* Ghose (after Ghose); 10, 11. *Microcoleus delicatulus* v. *attenuata* Ghose (after Ghose); 12. *Schizothrix arenaria* v. *non-constricta* Ghose (after Ghose); 13–15. *Microcoleus chthonoplastes* forma (after Dixit).

Thallus thin, bright blue-green, yellowish, bundles delicate, lower portion adpressed, up to 1 mm long; filaments slightly bent, nearly parallel, united or tied together, unbranched; sheath thick, somewhat slimy, coloured violet by chlor-zinc-iodide; trichome light blue-green, 1.5–3.5 μ broad, constricted at the cross-walls; cells somewhat shorter or up to twice as long as broad, 2.5–6 μ long; end cell conical, calyptra absent.

On mud near Rangoon (Skuja, 1949, 56).

According to Skuja the filaments in the Burmese plant are 2.5–3 μ broad and the trichomes are 2–2.7 μ broad.

### 3. **Symploca muscorum** (Ag.) Gomont

Essai class. homo., J. de. Bot., 4: 354, 1890; Monogr. Oscillariées, 110, pl. 2, fig. 9, 1892; Forti in De Toni, Sylloge Algarum, 5: 303, 1907; Frémy, Myxo. d'Afr. équat. franc., 126, 1929; Geitler, Kryptogamenflora, 1122, fig. 730, 1932; Frémy, Cyano. cotes d'Eur., 82, pl. 22, fig. 2, 1933.

Pl. 59, Figs. 3, 4

Filaments bent, forming a thin prostrate or creeping thallus, seldom erect, in bundles or forming a gelatinous *Phormidum*-like thallus, thallus blue-green or blackish; sheath thin, firm or more or less gelatinous, up to 2 μ thick, coloured violet by chlor-zinc-iodide; trichomes not constricted at the cross-walls, cross-walls not granulated; cells 5–8 μ broad, nearly quadratic or up to 2 times longer than broad, 5–11 μ long; end cell mostly broadly rounded, with slightly thickened outer membrane.

On submerged logs of a tree, Salt lakes, Calcutta (Martens, 1871a, 173; also Prain, 1905, 333; Biswas, 1926, 25); on wet rocks or damp tree trunks, Simla (Ghose, 1924, 340); on submerged parts of a plant, Borivli near Bombay (Dixit, 1936, 104), on mud, Calcutta (Banerji, 1938, 106), Shembaganur (Frémy, 1927, 46/47; 1942, 21) and Rangoon (Skuja, 1949, 57).

Ghose gives the thallus height as 7 mm and the breadth of the trichome 5–6 μ.

### 4. **Symploca muralis** Kützing ex Gomont

Kützing, Phyc. gene, 201, 1843; Gomont, Monogr. Oscillariées, 112, pl. 11, fig. 10, 1892; Forti in De Toni, Sylloge Algarum, 5: 304, 1907; Frémy, Myxo. d'Afr. équat. franc., 130, fig. 113, 1929; Geitler, Kryptogamenflora, 1124, fig. 732, 1932.

Filaments very much bent, thickly arranged, erect up to 2 mm long, in blackish blue tufts; sheath firm, seemingly thick, coloured by chlor-zinc-iodide; cells 3.4–4 μ broad, nearly quadratic, or up to 1/2 as long as broad, not constricted at the cross-walls; end cell obtuse conical, with slightly thickened outer membrane.

On damp soil or wall, Lahore (Ghose, 1924, 340), Berhampore (Rao, C. B., 1938b, 770), Shembaganur (Frémy, 1942, 21), Allahabad (Gupta, 1956, 79); epiphytic on submerged objects and plants, Rangoon (Skuja, 1949, 57).

Rao, C. B. (1937b, 375) has described a form occurring in moist soil in Benaras which differs in having broader trichomes (filaments 5.2–7.5 μ broad, sheath up to 2.5 μ thick; trichome (3.2–) 4–5 μ broad) and in the somewhat longer cells (2.4–5.6 μ).

### Var. **minor** Gardner

Univ. Calif. Publ. Bot., 14: 6, pl. 1, fig. 4, 1927; Geitler, Kryptogamenflora, 1125, fig. 733, 1932.

Pl. 59, Fig. 5

Filaments in very small bundles; sheath thin, colourless; trichome 3–3.4 μ broad; end cell with thickened membrane.

On moist soil, Calcutta (Banerji, 1938, 106).

Banerji gives the dimensions of the algae as follows: cells 3–3.5 μ broad and 3–6 μ long.

### 5. **Symploca flaccida** Zanardini

Phyc. Indic. pugillus, Mém. roy. Inst. Veneto, 17: 33, pl. 11B, figs. 1–3, 1872; Forti in De Toni, Sylloge Algarum, 5: 304, 1907.

Fascicles solitary, flaccid, pale bluish, filaments bent uniting at the apices, with sheath 15 μ broad; trichome 4–5 μ diam; cells indistinct, 1/2–1/3 as long as broad; sheath thick, colourless, pellucid.

Between mosses at Pedro-talla-galla, Ceylon (Zanardini, *loc. cit.*).

### 6. **Symploca elegans** Kützing ex Gomont

Kützing, Phyc. gene., 201, 1843; Gomont, Monogr. Oscillariées, 116, 1892; Forti in De Toni, Sylloge Algarum, 5: 309, 1907; Frémy, Myxo. d'Afr. équat. franc., 132, fig. 116, 1929; Geitler, Kryptogamenflora, 1128, 1932.

Bundles erect, blue-green in colour, anastomosing; filaments bent, flexuous, parallel, agglutinated; sheath seemingly thick, coloured violet by chlor-zinc-iodide; trichome blue-green, 1.3–2 μ broad, slightly constricted at the cross-walls, cross-walls not granulated; cells as long as broad or longer, 2–4 μ long; end cell sub-conical, rounded, calyptra absent.

Rangoon in Burma (Skuja, 1949, 56).

Skuja designates the Rangoon alga as a *forma*. The trichomes are 1–1.3 μ broad and the cells 1–2 μ long.

### 7. **Symploca parietina** (A. Br.) Gomont

Monogr. Oscillariées, 116, 1892; Forti in De Toni, Sylloge Algarum, 5: 311, 1907; Frémy, Myxo. d'Afr. équat. franc., 133, fig. 117, 1929; Geitler, Kryptogamenflora, 1129, 1932.

Filaments tortuous, forming small erect or prostrate anastomosing yellowish grey tufts; sheath seemingly thick, outer uneven, not coloured violet by chlor-zinc-iodide; cells 1.8–3 μ broad, longer than broad, 3.5–7 μ long, yellowish green; trichome not constricted at the cross-walls, septa inconspicuous, rarely with 2 granules; end cell rounded, calyptra absent.

On moist situations in Colombo (Ferguson ex Gomont, 1892, 116).

### 8. **Symploca thermalis** (Kütz.) Gomont

Monogr. Oscillariées, 114, pl. 2, figs. 15 and 16, 1892; Forti in De Toni, Sylloge Algarum, 5: 307, 1907; Frémy, Myxo. d'Afr. équat. franc., 131, fig. 114, 1929; Geitler, Kryptogamenflora, 1127, fig. 736, 1932.

Filaments forming densely arranged erect bundles, bright blue-green, up to 1 mm high; densely intricate at the base, above parallel, densely arranged sometimes branched; sheath very thin, sometimes slimy, not coloured violet by chlor-zinc-iodide; trichome 1.2–2 μ broad, blue-green, constricted at the cross-walls, with a single granule; cells 2–3 times as long as broad, rarely subquadrate, 1.7–5 μ long; end cell rounded.

Among mosses, Tonglu (Carter, 1926, 267); as a scum in a pond or on aquatic plants, Rangoon (Skuja, 1949, 57), and Allahabad (Gupta, 1956, 79).

### 9. **Symploca cartilaginea** (Mont.) Gomont

Monogr. Oscillariées, 113, pl. 2, figs. 13–14, 1892; Forti in De Toni, Sylloge Algarum, 5: 306, 1907; Geitler, Kryptogamenflora, 1126, fig. 734, 1932.

Pl. 59, Figs. 1, 2

Filaments arranged densely and parallel, forming bundles up to 1 cm high, dull blue-green; sheath seemingly thick, firm, coloured violet by chlor-zinc-iodide; cells 2–3 μ broad, mostly longer than broad, 3–5.6 μ long, not constricted at the cross-walls, blue-green; end cell obtuse with a very slightly thickened outer membrane.

On damp or wet soil and rocks, Rangoon (Ghose, 1927a, 22; 1927e, 81); Bombay (Dixit, 1936, 105).

Dixit gives the diameter of the filaments as up to 4.5 μ.

## SPECIES INQUIRENDAE

### **Symploca kurziana** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc. Bengal, 42(2): 179, 1873a; Hedwigia, 12: 170, 1873b; Forti in De Toni, Sylloge Algarum, 5: 312, 1907.—On the bottom of a boat on the Myitnan stream at Thabyegon, Pegu, Burma (Zeller, *loc. cit.*, also Theobald, 1883, 22).

### **Symploca lutescens** Zeller

Algae collected by Mr. S. Kurz. in Arracan and British Burma, J. Asiatic Soc. Bengal, 42 (2), 179, 1873a; Hedwigia, 12: 170, 1873b; Forti in De Toni, Sylloge Algarum, 5: 311, 1907.—In Irrawady flats and bottoms of boats in Hleing River, Pegu, Burma (Zeller, *loc. cit.*; also Theobald, 1883, 22).

## **SIROCOLEUS** Kützing

Species Algarum, 259, 1849; Gomont, Monogr. Oscillariées, 347, 1892.

Filaments very long, in tufts, nearly dichotomously branched; sheath firm, or only a little gelatinizing, colourless, cylindrical, not lamellated, not coloured violet by chlor-zinc-iodide; trichomes very many in a sheath, often arranged in bundles, with straight ends; end cells conical, not capitate.

Type species: *S. guyanense* Kütz.

### **Sirocoleus kurzii** (Zeller) Gomont

Monogr. Oscillariées, 349, pl. 14, figs. 3 and 4, 1892; Forti in De Toni, Sylloge Algarum, 5: 370, 1907; Geitler, Kryptogamenflora, 1131, fig. 738, 1932; Frémy, Cyano. cotes d'Eur., 72, pl. 18, fig. 4, 1933.

= *Hydrocoleum kurzii* Martens in Krempelhuber, Flora, 52: 234/235, 1869.

= *Chthonoblastus kurzii* Zeller, Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42 (part 2): 175, 1873a.

Pl. 47, Fig. 5

Filaments forming a soft, ascending, dirty to yellowish green, loosely aggregated fascides with closely adpressed branches; sheath colourless, gelatinous, seemingly thick, smooth or transversely striated; trichome blue-green or violet, apices acuminate, not constricted at the cross-walls, 7–10 μ broad, parallel, seemingly straight or spirally contorted; cells 1/2–1/4 as long as broad, 2–4 μ long, frequently granulated at the cross-walls; end cells obtuse conical.

On large marine algae and on submerged roots of rhizophores at Elephant point, Pegu (Zeller, *loc. cit.*) and at Bandra seaface, Malabar Hill in Bombay (Boergesen, 1935, 6); muddy banks of canals and salt lakes, Calcutta (Biswas, 1926, 25).

### SPECIES INQUIRENDA

**Sirocoleus indicus** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc. Bengal, 42: 178, 1873a; Hedwigia, 12: 170, 1873b; Forti in De Toni, Sylloge Algarum, 5: 370, 1907.—On sea washed rocks, Akyab, Burma (Zeller, 1873a, 178; 1873b, 170, Theobald, 1883, 23).

Geitler (1932) doubts whether this is an Oscillatoriaceae at all especially because of the longitudinally dividing gonidia. Forti (1907) feels that this may be a heterocystous ( ? ) form.

## MICROCOLEUS Desmazieres

Catal. pl. Botanagr belg., 7, 1823; Gomont, Monogr. Oscillariées, 350, 1892.

Filaments unbranched or sparsely branched; sheath mostly colourless, more or less regularly cylindrical, not lamellated, sometimes when old, gelatinizing; trichomes very many in each sheath, densely aggregated, often coiled or contorted like a rope; ends straight, mostly attenuated; end cell more or less conical seldom capitate.

Type species: *M. vaginatus* (Vaucher) Gomont ( = *M. terrestris* Desm.).

The genus varies only slightly from *Sirocoleum* and *Hydrocoleum*. Together with these it differs from the rest of the *Vaginariae* in having many trichomes in a common mucilaginous sheath.

### KEY TO THE SPECIES

1. Terrestrial, trichomes capitate with calyptra ............ 1. *M. vaginatus* (p. 343)
1. In freshwater or salt water ........................................ 2
    2. In salt water ........................ 2. *M. chthonoplastes* (p. 343)
    2. In freshwater, trichomes not capitate, without calyptra................ 3
3. Trichomes about 2 μ broad ........................ 3. *M. acutissimus* (p. 344)
3. Trichomes broader........................................ 4
    4. Trichomes constricted........................................ 5
    4. Trichomes not constricted ..................... 4. *M. paludosus* (p. 344)
5. Trichomes 4-5 μ broad, coloured blue by chlor-zinc-iodide 5. *M. subtorulosus* (p. 345)
5. Trichomes 6–10 μ broad, not coloured blue by chlor-zinc-iodide 6. *M. lacustris* (p. 345)
5. Trichomes 2.7–3 μ broad ........................ 7. *M. sociatus* (p. 346)

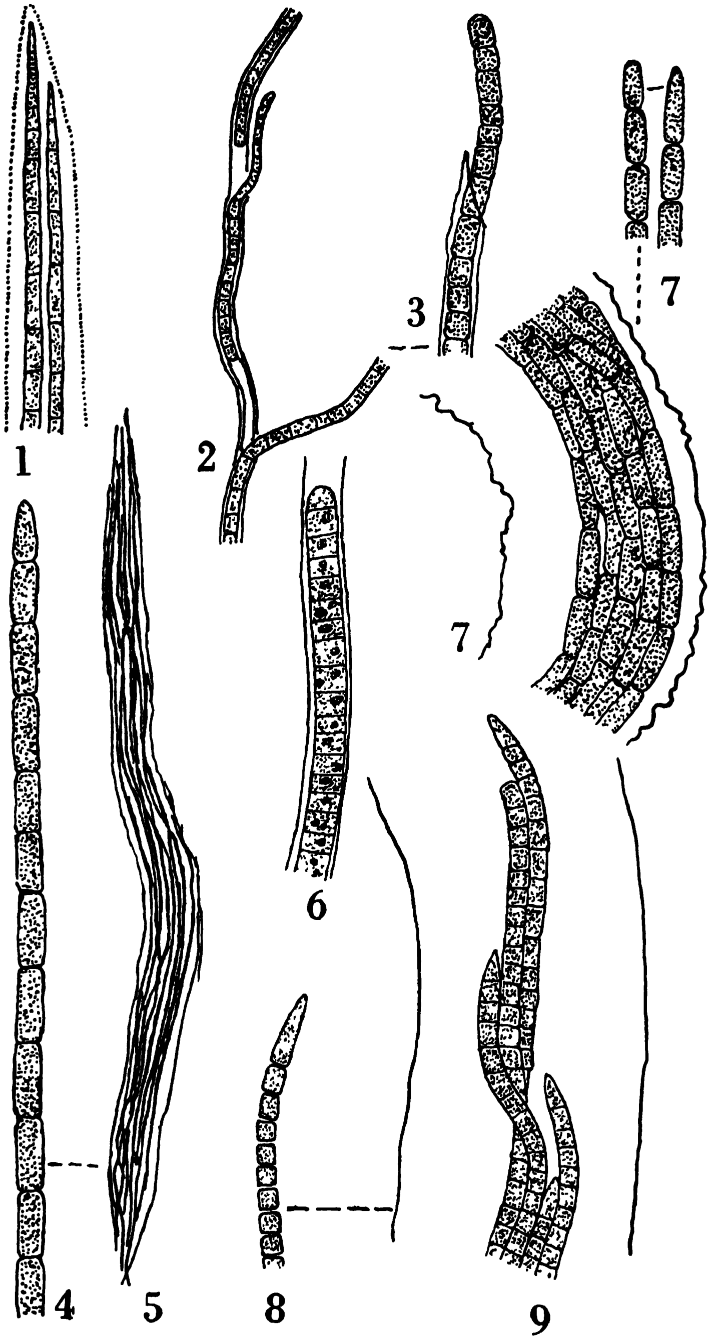

PLATE 60, Figs. 1–9.

1. *Microcoleus acutissimus* Gardner (after Gardner); 2, 3. *Symploca hydnoides* Kütz. (var. *a* Gomont) (after Gomont); 4, 5. *Microcoleus lacustris* (Rabenh.) Farl. (after Frémy); 6. *Symploca hydnoides* (var. *b*. Gomont) (after Gomont); 7, 8, 9. *Microcoleus chthonoplastes* Thur. (7 after Bharadwaja, 8, 9 after Gomont).

### 1. **Microcoleus vaginatus** (Vaucher) Gomont

Essai class. Nostocacées homocystées, Morot's J. de Bot., 4: 353, 1890; Monogr. Oscillariées, 355, pl. 14, fig. 12, 1892; Forti in De Toni, Sylloge Algarum, 5: 374, 1907; Frémy, Myxo. d'Afr. équat. franc., 78, fig. 79, 1929; Geitler, Kryptogamenflora, 1136, fig. 741, 1932.

Pl. 56, Fig. 3

Filaments single, creeping or forming a dark green thallus, coiled, sometimes sparsely branched; sheath colourless, uneven, not coloured violet by chlor-zinc-iodide, sometimes gelatinizing, many often agglutinated with one another, attenuated at the ends; cells 3.5–7 μ broad, subquadrate or ½–2 times as long as broad, 3–7 μ long, often granulated at the cross-walls, but not constricted, blue-green or dirty green; end cells capitate, with a flat conical calyptra.

On moist soils.—Lahore (Ghose, 1919, 11; 1924, 240); Tibet (Schmidle ex De Toni, 1907, 374).

### 2. **Microcoleus chthonoplastes** Thuret ex Gomont

Thuret, Ann. Sci. nat. Bot. 6th ser., 1: 378, 1875; Gomont, Monogr. Oscillariées, 353, pl. 14, figs. 5–8, 1892; Forti in De Toni, Sylloge Algarum, 5: 371, 1907; Frémy, Myxo. d'Afr. équat. franc., 78, fig. 78, 1929; Geitler, Kryptogamenflora, 1133, fig. 739, 1932.

= *Chthonoblastus salinus* Kütz., Phyc. gene., 197, 1843.

= *Chthonoblastus lyngbyei* Kütz., Phyc. gene., 197, 1843.

Pl. 60, Figs. 7–9

Filaments single, or forming an expanded dirty to dark green lamellated thallus, coiled, seldom branched; sheath sometimes gelatinizing, uneven, thick, not coloured violet by chlor-zinc-iodide, having many closely grouped trichomes; trichome constricted at the cross-walls, 2.5–6 μ broad, not granulated at the cross-walls; cells 1–2 times as long as broad, blue-green, 3.6–10 μ long; end cells not capitate; pointed conical.

On sea coasts, on brickwalls, on soil, in land, usar soils, salt water areas etc., with other algae in freshwaters — Salt Lakes, Calcutta, and Hooghly river (Martens, 1870b, 259; also Prain, 1905, 334; Martens, 1871a, 272; Biswas, 1926, 26; Banerji, 1938, 107; Biswas, 1942, 138), Dadar (Schmidle, 1900b, 161), Bandra seaface (Boergesen, 1935, p. 6), and Karwar in Bombay State (Iyengar and Desikachary, 1944, 64); Chilka lake, Orissa (Biswas, 1932b, 189; 1932d, 318); Shillong, Assam (Biswas, 1934, 15); Benaras, Basti, Gorakhpur and Mirzapur, Siwait near Allahabad in Uttar Pradesh (Bharadwaja, 1935, 98; Rao, C. B., 1937b, 375; Singh, R. N., 1939a, 61; Mitra, 1951, 360/362); Narsapur, Namdur, Coconada in Andhra (Rao, C. B., 1938a, 96); Muzaffarpur in Bihar (Rao, C. S., 1939, 150); Chamba in Punjab (Singh, V. P., 1941, 253); on chanks from Rameshwaram in Madras State (Iyengar and Desikachary, 1944, 64); Cape Comorin (Venkataraman, 1957, p. 473); Ceylon and Galle (Ferguson's collection ex Gomont, 1892, 353; Iyengar and Desikachary, 1944, 64); Akyab and Rangoon in Burma (Zeller, 1873b, 172; Theobald, 1883, 23).

Dixit (1936, p. 105, figs. 4A, D) describes a form (pl. 57, figs. 13–15) where the trichomes are arranged in 2–4 bundles in each sheath, the outer limit of which is more or less wrinkled and show folds on its sides like those of *M. annulatus*. The trichomes are unconstricted (filaments 27–45 μ broad; sheath 8–37.5 μ thick; trichomes 3.7–4.2 broad; cells 4.5–7 μ long).

### 3. **Microcoleus acutissimus** Gardner

New Myxophyceae from Porto Rico, Nem. N. Y. Bot. Gdn., 7: 55, pl. 11, fig. 2, 1927; Geitler, Kryptogamenflora, 1138, fig. 744a, 1932, em. Drouet, Amer. J. Bot., 24: 603, 1937.

Incl. *M. delicatulus* West et West var. *attenuatus* Ghose, J. Burma Res. Soc., 16: 223, pl. 11, fig. 7, 1927a.

Pl. 60, Fig. 1

Filaments nearly straight, 400–450 (-500) μ long, 20–35 μ broad, with 15–30 trichomes; sheath colourless, uneven, more or less gelatinous; trichomes mostly parallel, not constricted at the cross-walls, cross-walls frequently granulated, ends long, attenuated and pointed, 1.7–2.3 μ broad; cells 2–4 times as long as broad, 3.5–8 μ long, pale blue-green; end cell very acutely conical.

On soil, Rangoon (Ghose, 1927a, 223; 1927e, 81).

Ghose (1927a, 223) described *M. delicatulus* var. *attenuatus* (pl. 59, figs. 10, 11) and it resembles very closely *M. acutissimus* Gardner. Geitler (1932, 1141) suggests that the two are identical.

### 4. **Microcoleus paludosus** (Kütz.) Gomont

Monogr. Oscillariées, 358, pl. 14, fig. 13, 1892; Forti in De Toni, Sylloge Algarum, 5: 376, 1907; Frémy, Myxo. d'Afr. équat. franc., 80, fig. 80, 1929; Geitler, Kryptogamenflora, 1144, fig. 753, 1932.

Pl. 56, Fig. 2

Filaments single or forming a dark blue-green stratum, unbranched or sometimes divided at the end; sheath slightly gelatinous, not coloured violet by chlor-zinc-iodide, with many straight or rope like trichomes; trichomes not granulated at the cross-walls, constricted at the cross-walls, 5–7 μ broad; cells nearly as long as or twice as long as broad, 4–13 μ long, bright blue-green; end cell not capitate, conical.

On moist walls, moist soil and in stagnant waters — Berkuda island, Chilka lake in Orissa (Biswas, 1924, 362; 1932, 189); Calcutta (Biswas, 1925, 6; Banerji, 1938, 107); Shembaganur in Madras State (Frémy, 1927, 26; 1942, 21).

Filaments in the Shembaganur material were 15–25 μ broad and the trichomes 5–6 μ broad.

### 5. **Microcoleus subtorulosus** (Bréb.) Gomont

Essai class. Nostocacées homocystées, J. de Bot., 4: 352, 1890; Monogr. Oscillariées, 369, pl. 14, figs. 14–15, 1892; Forti, in De Toni, Sylloge Algarum, 5: 378, 1907; Geitler, Kryptogamenflora, 1143, fig. 751, 1932.

Pl. 56, Figs. 8, 9

Thallus bluish, growing extensively on shells or on water plants; sheath very gelatinous, coloured violet with chlor-zinc-iodide; with many trichomes; trichomes straight, at the ends gradually attenuated, 6–10 μ broad distinctly constricted at the cross-walls; cells 5–10 μ long, mostly short barrel-shaped; end cell not capitate, conical or cylindrical conical.

Type not recorded.

R. N. Singh (1939b, 68) has described a specimen found growing on the surface of water at Gorakhpur. According to him it differs in possessing shorter cells (Filaments 13.2–20 μ broad, sheath 8–39.6 μ thick, trichomes 6.6–9.9 μ broad, cells 4–5.5 μ long).

### 6. **Microcoleus lacustris** (Rabenh.) Farlow

Alg. es. Am. bor., nr. 227 bis, 1877; Gomont, Monogr. Oscillariées, 359, 1892; Forti, in De Toni, Sylloge Algarum, 5: 376, 1907; Frémy, Myxo. d'Afr. équat. franc., 80, fig. 81, 1929; Geitler, Kryptogamenflora, 1142, figs. 749, 750a, 1932.

Pl. 60, Figs. 4, 5

Thallus blackish blue-green, filaments contorted, seldom branched; sheath colourless, slimy, not coloured violet by chlor-zinc-iodide, sometimes gelatinising, many trichomes in each; trichomes distinctly constricted at the cross-walls, 4–5 μ broad; cells cylindrical, 1–3 times as long as broad, 6–12 μ long, bright blue-green; end cell more or less rounded, conical, not capitate.

Judson College, Rangoon (Skuja, 1949, 57).

forma **minor** nom. nov.

= *M. lacustris* forma. Rao, C. S., Proc. Indian Acad. Sci., B, 11: 131, 1940.

Filament 30–45 μ broad, trichome 2–3 μ broad, cells up to 6 μ long; end cell acutely tapering.

On cemented floor near water tap, Delhi (Rao, C. S., *loc. cit.*).

Rao's form differs in having narrower trichomes and more acutely tapering apical cell. Frémy (1929) gives the breadth of the trichome as 3.6–4 μ broad and this form appears to be narrower still.

### 7. **Microcoleus sociatus** West et West

Welwitch Freshw. Afr. Alg., J. Bot. Lond., 35: 272, 1897; Forti, in De Toni, Sylloge Algarum, 5: 377, 1907; Frémy, Myxo. d'Afr. équat. franc., 84, fig. 85, 1927; Geitler, Kryptogamenflora, 1141, fig. 746, 1932.

Filaments single, unbranched, long, in some places bent, 54–65 μ broad; sheath firm, colourless, open at the ends, 9–13 or more trichomes in each; trichomes constricted at the cross-walls, not granulated, 2.7–3 μ broad; cells 2–3 times as long as broad, cylindrical; end cell conical and pointed, up to 5 times as long as broad.

On moist soil. — Benaras (Rao, C. B., 1937b, 375); Rangoon and Kyaktan in Burma (Skuja, 1949, 57). Also in a paddy-field at Tirupati (!).

## SPECIES INQUIRENDA

### **Microcoleus burmanicus** (Zeller) comb. nov.

= *Chthonoblastus burmanicus* Zeller, Algae collected by Mr. S. Kruz in Arracan and British Burma, J. Asiatic Soc. Bengal, 42: 169, 1873a; Hedwigia, 12: 178, 1873b.—In near Henzadah, Pegu.

## SPECIES EXLUDENDA

*Microcoleus aitschisonii* Schaarschmidt Afghanistan Algae, J. Linn. Soc. Bot., 21: 241, pl. 5, fig. 1, 1886 — Sticking to *Anmania,* Afghanistan. Gomont (1892, 362) excludes this as a heterocystous form.

## **HYDROCOLEUM** Kütz.

Phyc. gene., 196, 1843; Gomont, Monogr. Oscillariées, 332, 1892.

Few trichomes in gelatinous, mostly colourless sheath, sheath in older ones diffluent; filaments more or less branched, forming a tuft or membranaceous thallus; ends of trichome straight, more or less attenuated and capitate; end cells often with calyptra.

Type Species: *H. homoeotrichum* Kütz.

Eight species have been reported in the last century and have not since been reported. Of these only one species, *H. cantharidosum* (Mont.) Gom. has been described by Gomont (1892a, 336) as occurring in this region.

### KEY TO THE SPECIES

1. Marine .................................................... 2
1. Freshwater .................................................... 3
    2. Trichome 18–24 μ broad .................... 1. *H. cantharidosum* (p. 347)
    2. Trichome 8–16 μ commonly 9–11 μ broad ..... 2. *H. lyngbyaceum* (p. 347)
3. Trichome 3–7 μ broad .................... 3. *H. meneghinianum* (p. 348)
3. Trichome 4–5.5 μ broad .................... 4. *H. violaceum* (p. 348)
3. Trichome 16–19 μ broad .................... 5. *H. heterotrichum* (p. 348)

### 1. **Hydrocoleum cantharidosum** (Mont.) Gomont

Essai class. Nostocacées homocystées, Morots. J. de Bot., 4: 353, 1890; Monogr. Oscillariées, 336, pl. 12, figs. 6–7, 1892; Forti, in De Toni, Sylloge Algarum, 5: 316, 1907; Geitler, Kryptogamenflora, 1148, fig. 755, 1932.

Pl. 46, Figs. 4, 5

Thallus bushy, olive-green or blackish or dark-green; up to 2 cm high, gelatinous; filaments straight, sparsely branched, with closely adpressed branches; sheath up to 2 times thicker than the trichome, very slimy, uneven, occasionally lamellated; trichome blue-green few in each sheath nearly parallel, in the upper parts of filaments single in each sheath, not constricted at the cross-walls, 18–24 μ broad; cells 1/5–1/9 as long as broad, 2.4–4 μ long, cross-walls sometimes granulated; apices tapering and pointed with calyptra.

Ceylon (Ferguson's Collection, *see* Gomont, 1892a, 336).

### 2. **Hydrocoleum lyngbyaceum** Kützing ex Gomont

Kützing, Species Algarum, 259, 1849; Gomont, Monogr. Oscillariées, 337, pl. 12, figs. 8–10, 1892; Forti, in De Toni, Sylloge Algarum, 5: 317, 1907; Frémy, Myxo. d'Afr. équat., franc., 89, 1929; Geitler, Kryptogamenflora, 1150, fig. 757, 1932; Frémy, Cyano. cotes d'Eur., 72, pl. 19, fig. 1, 1933.

Pl. 46, Figs. 1, 2, 6

Thallus caespitose tufts, dark to blackish green, gelatinous and expanding; filaments unbranched at the base and richly branched above, branches closely adpressed; sheath broad, gelatinous, uneven, somewhat totally diffluent; trichome yellow-green, many in each sheath, spirally coiled, in the branches single, 8–16 μ (commonly 9–11 μ) broad, granulated at the cross-walls, not constricted at the cross-walls; cells 1/3–1/6 as long as broad, 2.5–4.5 μ long; ends truncated attenuated, with calyptra, outer membrane of the end cell thickened.

On brackish mud, Akyab, Burma (Theobald, 1883, 24).

### 3. **Hydrocoleum meneghinianum** Kützing

Species Algarum, 259, 1849; Rabenhorst, Fl. Eur. Alg., 2: 151, 1865; Forti, in De Toni, Sylloge Algarum, 5: 325, 1907.

Thallus caespitose, brownish green, rigid, 2–6 mm thick; sheath moderately thick, rigid, opaque, penicillately divided apices, first colourless, later brownish; trichomes generally three together, 3–7 μ broad, in contorted fascicles; cells indistinct, pale green, not granulated.

In a mangrove swamp, Elephant point, Burma (Zeller, 1873b, 178; also Theobald, 1883, 23).

### 4. **Hydrocoleum violaceum** Martens

A fifth list of Bengal algae etc., Proc. asiatic Soc., Bengal, 40: 170, 1871a; Geitler, Kryptogamenflora, 1152, 1932.

Thallus in tufts, dull violet; sheath thin, with 3 or more trichomes; trichomes violet, 4–5.5 μ broad; cells up to $\frac{1}{2}$ as long as broad; end cell conical rounded.

In standing waters, Calcutta (Martens, *loc. cit.*).

### 5. **Hydrocoleum heterotrichum** Kütz. em. Gomont

Essai class. Nostocacées homocystées, Morots. J. de Bot., 4: 353, 1890; Monogr. Oscillariées, 342, pl. 13, figs. 3–4, 1892; Forti in De Toni, Sylloge Algarum, 5: 320, 1907; Frémy, Myxo. d'Afr. équat. franc., 85, fig. 86, 1929; Geitler, Kryptogamenflora, 1153, 1932.

Pl. 46, Figs. 3, 9

Filaments blackish, up to 5 mm high, arranged in tufts, with repeated erect false branches, sometimes with calcium in crustation; sheath somewhat slimy, uneven, often transversely plicate, at the ends pointed; trichomes mostly straight or somewhat spirally contorted, not constricted at the cross-walls, 16–19 μ broad; cells 1/3–1/5 times as long as broad, 3.4–4.5 μ long, brownish-green; end cells capitate, round truncated.

Manbhum (Martens, 1870a, 11); Parel and Matunga in Bombay (Schmidle, 1900b, 161).

## SPECIES NON SATIS COGNITA

### **Hydrocoleum striatum** Zeller

Algae collected by S. Mr. Kruz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42 (part 2): 178, 1973a; Hedwigia, 12: 170, 1873b; Forti, in De Toni, Sylloge Algarum, 5: 325, 1907.

Thallus up to 1 cm diam., blackish blue; sheath about 25 μ diam., thick, transversely striated, lamellae 4 in 10 μ; filaments mostly 3 in a sheath, contorted, 12.5 μ broad, granulated, indistinctly articulated, cells much shorter than broad.

Pegu, in a stream near Sengyae-wa, near Rangoon (Zeller, *loc. cit.*).

## SPECIES INQUIRENDAE

### **Hydrocoleum lenormandi** Martens

Proc. asiatic Soc., Bengal, 40: 173, 1871a; Prain, Rec. bot. Surv. India, 334, 1905; — on submerged grasses in salt lakes, Calcutta.

### **Hydrocoleum viridula** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc. Bengal, 42 (part 2); 177, 1873b. — Burma (Zeller, *loc. cit.*).

## Family NOSTOCACEAE Kützing

Phycologia generalis, 203, 1843.

Trichomes free or in a common mucilage, generally with cells in a single row, cells generally similar throughout, ends or end cells sometimes attenuated, with intercalary growth; sheath thick and gelatinous or thin and firm; hormogones present; heterocysts present or absent, when present intercalary or terminal, generally single, in some more than one together; spores present or absent, single or in series, formed in a definite manner beginning from near the heterocyst or in between two of them.

This family as delimited by Bornet et Flahault contained eight genera. Since then *Anabaenopsis, Richelia* and *Pseudanabaena* have been described. While the position of *Anabaenopsis* has been accepted, there is difference of opinion regarding the other two. Fritsch (1945) is of the opinion that *Pseudanabaena* is more closely related to the Nostocaceae as a non-heterocystous form than to the Oscillatoriaceae. Abundant evidence exists that even in the same species of *Anabaena* heterocysts are not at all or rarely formed during one or more stages in their development. Another genus of doubtful position is *Isocystis*. Bornet and Flahault (1880, p. 180) placed it at the end of Nostocaceae under " Anhang ". Geitler (1932) placed it in the Oscillatoriaceae. He, however, included it in the Nostocaceae in 1942 (*see* Geitler. 1942, p. 177). Fritsch (1945, p. 835) keeps it in the Nostocaceae on account of the presence of spores in chains.

It was Lemmermann (1910, p. 196) who first created Microchaetaceae to include forms with a firm sheath such as *Microchaete, Aulosira* and *Desmonema.* Geitler (1925a, 1925b, 1932) removes *Desmonema* to the Scytonemataceae (*see* also Frémy, 1929) and includes *Hormothamnion* in the Microchaetaceae. Fritsch (1944, p. 245) suggests greater affinity of *Aulosira* with the Nostocaceae than with the Microchaetaceae. The mode of growth, the presence of a clear distinction between the base and apex and the presence of a basal heterocyst in *Microchaete* make any relationship between *Microchaete* and *Aulosira* remote. On the other hand *Aulosira* and *Hormothamnion* resemble very much *Nodularia* and these should be placed in the Nostocaceae (Bornet and Flahault, 1880; Kirchner, 1898; Frémy, 1929).

In so doing one is aware of the difference these have with the rest of the Nostocaceae and a reversion to Bornet et Flahault's (*see* also Kirchner, 1898, p. 76) practice of dividing the Nostocaceae in two sub-families is very desirable. Nostocaceae is divided into Anabaeneae and Aulosireae. The latter will include *Aulosira, Hormothamnion* and *Nodularia.* Elenkin (1938, p. 358) has earlier pointed out a similar affinity but by creating a new family Nodulariaceae to include *Nodularia, Aulosira* and *Microchaete.*

*Richelia* with the development of heterocyst at both the ends is more related to the Nostocaceae than to the Microchaetaceae. The writer does not agree with Fritsch (1942, p. 1945) in placing it in the Microchaetaceae.

Elenkin (1938, p. 548–49) divides the nostocaceous genera into three families, Aphanizomenonaceae, Nostocaceae and Anabaenaceae. Such a division separates genera very widely which are otherwise very closely related and which at times are very difficult to distinguish (for instance *Anabaena ambigua* and *Wollea, see* R. N. Singh, 1942; Ghose and Randhawa, 1936b; Fritsch, 1945, 1949: 1951). Such a step is not followed here. Similarly the author is not in favour of dividing *Nostoc* into a number of genera, as has been done by Elenkin (1938) viz. *Amorphonostoc, Sphaeronostoc, Stratonostoc* and *Nematonostoc.*

Drouet (1951, p. 165) places *Microchaete* ( = *Fremyella*) and *Aulosira* in Scytonemataceae. He places *Hormothamnion* in the Nostocaceae.

The genus *Raphidiopsis* like *Isocystis* appears to be more related to the Nostocaceae than to other families (*see* also Geitler, 1942; Drouet, 1951).

The genus *Anabaenothrix* was created to include three species of *Anabaena* whose trichomes are sheathed (Randhawa, 1936). The genus is considered to be not distinct from *Anabaena* (*see* Rao, C. B., 1937, p. 106; Geitler, 1942, p. 184; Fritsch, 1945, p. 835; 1949, p. 153).

## KEY TO THE GENERA

| | | |
|---|---|---|
| 1. | Trichomes without firm sheath | 2 |
| 1. | Trichomes with a firm sheath | 10 |
| 2. | Trichomes generally endophytic | *Richelia* (p. 351) |
| 2. | Trichomes generally not endophytic | 3 |
| 3. | Heterocysts present | 4 |
| 3. | Heterocysts absent | 9 |
| 4. | Intercalary heterocysts generally in pairs | *Anabaenopsis* (p. 353) |
| 4. | Intercalary heterocysts generally single | 5 |
| 5. | Heterocysts present commonly terminally with a single large spore adjoining | *Cylindrospermum* (p. 359) |
| 5. | Heterocysts rarely terminal, generally intercalary | 6 |
| 6. | End cells elongated, hair like, colourless | *Aphanizomenon* (p. 359) |
| 6. | End cells not so | 7 |
| 7. | Filaments single or in a formless gelatinous mass | *Anabaena* (p. 391) |
| 7. | Filaments generally in a definite colony | 8 |
| 8. | Thallus finger shaped, attached at first | *Wollea* (p. 370) |
| 8. | Thallus otherwise | *Nostoc* (p. 372) |
| 9. | Trichomes attenuated, often end cells pointed | *Raphidiopsis* (p. 420) |
| 9. | Trichomes with uniform cells | *Pseudanabaena* (p. 419) |
| 10. | Trichomes single within a sheath | 11 |
| 10. | Trichomes in parts of the thallus more than one in a sheath | *Hormothamnion* (p. 350) |
| 11. | Cells very short and discoid | *Nodularia* (p. 423) |
| 11. | Cells not discoid | *Aulosira* (p. 424) |

## Sub-family ANABAENAE

Bornet and Flahault, Revision des Nostocacées hétérocystées, 180, 1888.

Trichome with an inconspicuous sheath or with sheaths of diffluent mucilage.

### RICHELIA Schmidt Johs.

Plankton fra det Rode Hav og Adenbugten, Vidensk. Meddel. fra d. Naturh. Foren. Kjobenh., 147, 1901.

Plants mostly intracellular trichome without sheath, few-celled, straight or slightly bent, unformly broad; heterocysts at one end or sometimes at both ends; spores not known; hormogones not seen.

Monotypic: *R. intracellularis* Schmidt Johs.

When first described the alga was considered to be very similar to *Microchaete* excepting that a sheath is absent. But Karsten (Ind. Phytoplankton,

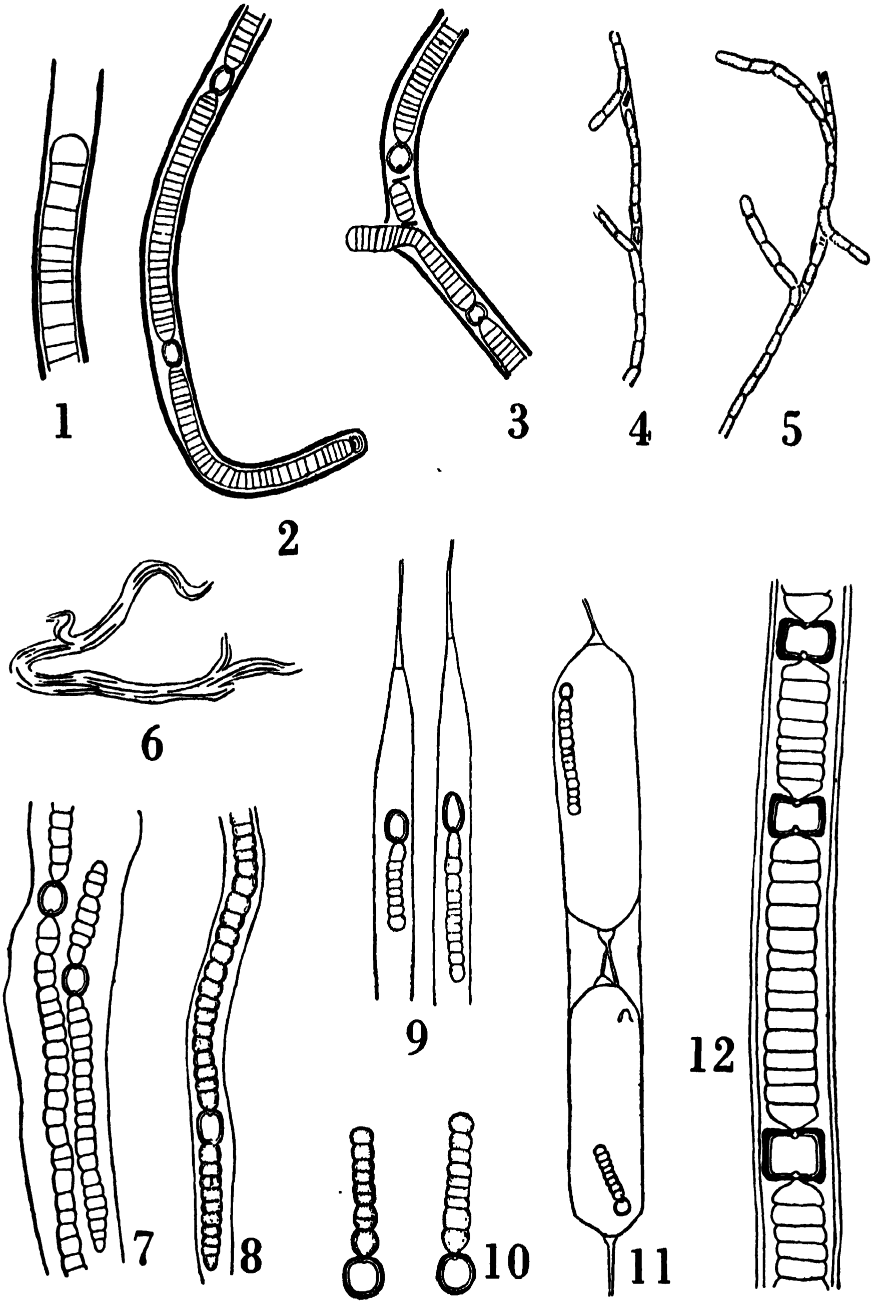

PLATE 61, Figs. 1–12.

1, 2, 3. *Microchaete aeruginea* Batters; 4, 5. *Plectonema terebrans* Born. et Flah.; 6, 7, 8. *Hormothamnion enteromorphoides* Grun.; 9–11. *Richelia intracellularis* Schmidt; 12. *Nodularia spumigena* v. *major* (Kütz.) Born. et Flah. (all after Iyengar & Desikachary).

Wiss. Ergebn. deutsch. Tiefsee Exped., 2: 2, 1907) observed the presence of two heterocysts, one at either end. The trichome often breaks into two each with a single heterocyst. Thus the alga bears a remote resemblance to *Cylindrospermum*. Fritsch (1945) however places the genus in the Microchaetaceae.

### **Richelia intracellularis** Johs. Schmidt

Schmidt, *loc. cit.,* 147, fig. 1901; Forti in De Toni, Sylloge Algarum, 5: 480, 1907: Geitler, Kryptogamenflora, 804, fig. 513, 1932; Frémy, Cyano. cotes d'Eur., 188, pl. 62, fig. 3, 1933.

Pl. 61, Figs. 9–11 & Pl. 15, Figs. 6–10

Trichome up to 105 μ long, 3–20 celled, straight or nearly bent, pale blue-green, 5.6–9.8 μ in diameter; cells barrel-shaped, after division half as long as broad; heterocysts at one end or sometimes at both ends, nearly spherical, 9.8–11.2 μ broad.

On *Chaetoceros contortum*, and in cells of *Rhizosolenia styliformis*, Indian Ocean (Karstan, 1907, 403); in the cells of *Rhizosolenia* spp., in the plankton off the Coast of Madras (Iyengar and Desikachary, 1944, 53; Subrahmanyan, 1946, 116–222).

Iyengar and Desikachary (1944, p. 53, fig. 16) report a form from the Madras Coast, whose trichomes are only 2.6–3.9 μ broad and heterocysts are about 5.2 μ broad.

## ANABAENOPSIS (Wolosz.) Miller sensu strict.

Zur Systematik der Gattung *Anabaena* Bory, Arch. Soc. russe Protistol. 2: 125, 1923; Woloszynska, Das Phytoplankton einiger javanischer Seen mit Berucksichtigung des Sawa. Planktons, Bull. Internat. Acad. Sci. Cracovie, ser. B, 6: 680, 1913 (as a section); Taylor, Notes on the genus *Anabaenopsis* Amer. J. Bot., 19: 454–63, 1932; Ramanathan, On a form of *Anabaenopsis* from Madras, J. Indian bot. Soc., 17: 325–39, 1938.

Trichomes free-swimming, short, spirally coiled, like an *Anabaena*; heterocysts terminal and intercalary, intercalary ones in pairs formed by the unequal division of two adjoining vegetative cells; spores intercalary and formed away from the heterocyst.

Type species: *A. elenkinii* Miller.

Aptekarj (De nova Cyanophycearum specie *Anabaenopsis Arnoldii* mihi, Bot. Mat. Inst. Sporov. Rast. Glav. Bot. Sad U.S.S.R. IV, Not. Syst. Inst. Crypt. Horti. Bot. Princi. U.S.S.R., 4: 41–55, 1926) has described in great

detail the formation of the paired heterocysts, substantiating Miller's observations. In a form of *Anabaenopsis arnoldii* from India, Ramanathan (1938) again observed the same details as those of Aptekarj. Taylor (1932) has followed the same in a number of species of *Anabaenopsis*.

Many algologists are agreed on this characteristic feature of the genus. Fritsch (1904, 1949) has described the formation of heterocysts in *Anabaena* and it differs very much from that present in this genus. The other character, the presence of terminal heterocyst is now considered as a not very important or distinguishing feature. Ramanathan (1938) has described that when an intercalary heterocyst becomes terminal by fragmentation then one of the pores of the heterocysts becomes plugged thus looking as though it were an one-pored heterocyst. Ramanathan reviewed the species of the genus and he delimits the genus to such members as have heterocysts formed in the manner described in *A. arnoldii* or *A. elenkinii*. He suggested relegating a number of species as *species incertae sedis* and the removal of *Anabaenopsis raciborskii* to *Anabaena*. One is not in agreement with Fritsch (1949, 138), that this genus is doubtfully distinct from *Anabaena*.

## KEY TO THE SPECIES

1. Heterocysts more or less spherical, constricted at the cross-walls ................ 2
1. Heterocysts elongate; constricted at the cross-walls ....... 1. *A. tanganyikae* (p. 354)
    2. With gas-vacuoles.................................. 3. *A. arnoldii* (p. 356)
    2. Without gas-vacuoles ............................ 2. *A. circularis* (p. 354)

### 1. **Anabaenopsis tanganyikae** (West, G. S.) Wolosz. et Miller

ex Miller, Systematik der Gatting *Anabaena*, Arch. Soc. russe Protistol., 2: 125, 1923; Frémy, Myxo. d'Afr. équat. franc., 374, fig. 310, 1929; Geitler, Kryptogamenflora, 808, fig. 516b, 1932.

Pl. 63, Figs. 4, 8

Trichome free-swimming, very short, spirally coiled, 1–2 (–3) μ mostly 1–1/2 spirals, without sheath; trichomes not constricted at the cross-wall 2.4–2.6 μ broad; cells cylindrical, 2–3 times longer than broad, 3.8–8.5 μ long, without gas-vacuoles; heterocysts ellipsoidal, 3 × 5.5 μ; spores ellipsoidal, single away from the heterocyst, 7 μ broad, 13 μ long, with colourless smooth membrane.

In a pool at Sonarpur ( ! )

The Indian alga is broader than the African one (cells 2.6–3.9 μ broad and 2.6–7.9 μ long; heterocysts 3.9–5.2 μ broad and 3.9–7.9 μ long).

### 2. **Anabaenopsis circularis** (G. S. West) Wolosz. et Miller

ex Miller, Arch. Soc. russe Protistol. 2: 125, 1923; Frémy, Myxo. d'Afr. équat. franc., 374, fig. 309, 1929; Geitler, Kryptogamenflora, 807, fig. 516a, 1932.

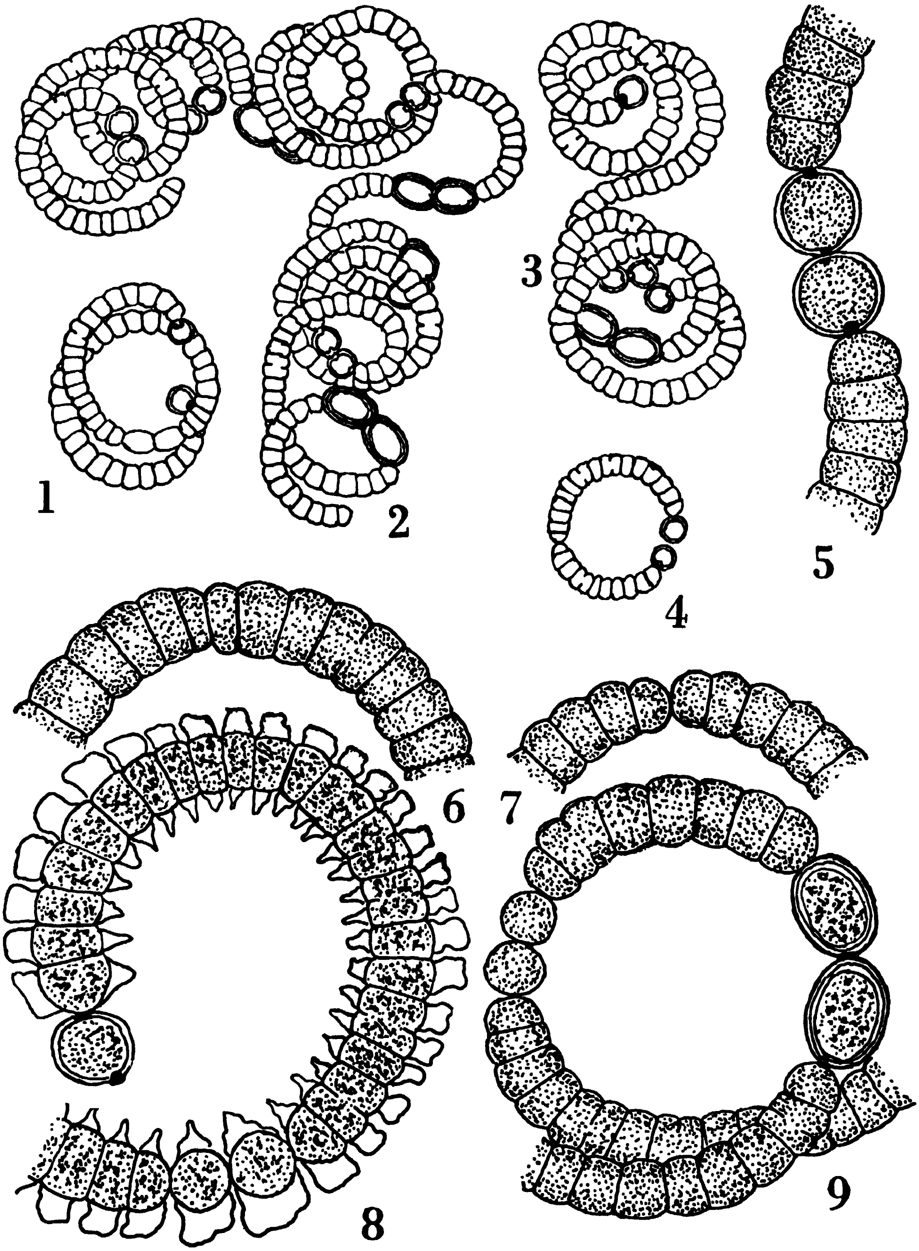

PLATE 62, Figs. 1-9.
*Anabaenopsis arnoldii* Aptekarj v. *indica* Ramanathan (after Ramanathan).

Trichomes free-swimming, very short, mostly spirally coiled, with 1–1½ spirals, very seldom straight, 4.5–6 μ broad; cells spherical or somewhat longer than broad, with a large granule; heterocysts spherical, 5–8 μ broad; spores not known.

Type not recorded.

### Var. **javanica** Wolosz.

Bull. Internat. Acad. Sc. Cracovie, B, 6: 681, fig. 9, 1912; Geitler, Kryptogamenflora, 808, fig. 517, 1932.

Pl. 63, Figs. 3, 5

Filaments short, spirally coiled, with 1–3 spirals, without gas-vacuoles, 5–8 μ broad; heterocysts often small, spherical; spores ellipsoidal, 12–14 μ broad, 16–18 μ long, with colourless membrane.

In a tank in Madras ( ! ).

Taylor (Amer. J. Bot., 19: 458, 1932; *see* also Elenkin, 1938, pp. 794–800 includes var. *javanica* Wolosz. under *A. arnoldii* as var. *javanica* (Wolosz.) Taylor.

### 3. **Anabaenopsis arnoldii** Aptekarj

De nova Cyanophycearum specie *Anabaenopsis arnoldii*, Not. Syst. Inst. Crypt. Horti Bot. Princi. U.S.S.R., 4: 54, figs. 1–8, 1926; Geitler, Kryptogamenflora, 809, fig. 519, 1932.

Pl. 5, Figs. 2–7

Trichome single, with a thick, hardly perceptible gelatinous sheath, regularly spirally coiled, ½–9 spirals, spirals 25–58 μ broad, 7–32 μ away from one another, with a heterocyst at one end, at the other one or two heterocysts, or seldom a spore; cells adpressed spherical, seldom nearly ellipsoidal, 6.5–8.5 μ broad or 7–9 μ broad, 6.5–8 μ long, with gas-vacuoles; heterocysts intercalary and terminal, two together rarely one, spherical 5.8–7 μ broad or ellipsoidal and 7–9.2 μ broad and 8–10.5 μ long; spores two together, seldom one, intercalary, ellipsoidal, 10.4–11.5 μ broad, 11.5–14.5 μ long, with a smooth colourless membrane.

Type not recorded.

### Var. **indica** Ramanathan

On a form of *Anabaenopsis* from Madras, J. Indian bot. Soc., 17: 325, Text-Figs. 1–15, pl. 1, figs. 1–4, 1938.

Pl. 62 & Pl. 63, Figs. 1, 2

Trichomes elongated, spirally coiled, coils ½–16 in number, spirals 30–80 μ broad, trichome 7.6–11.4 μ broad; cells short and barrel-shaped and

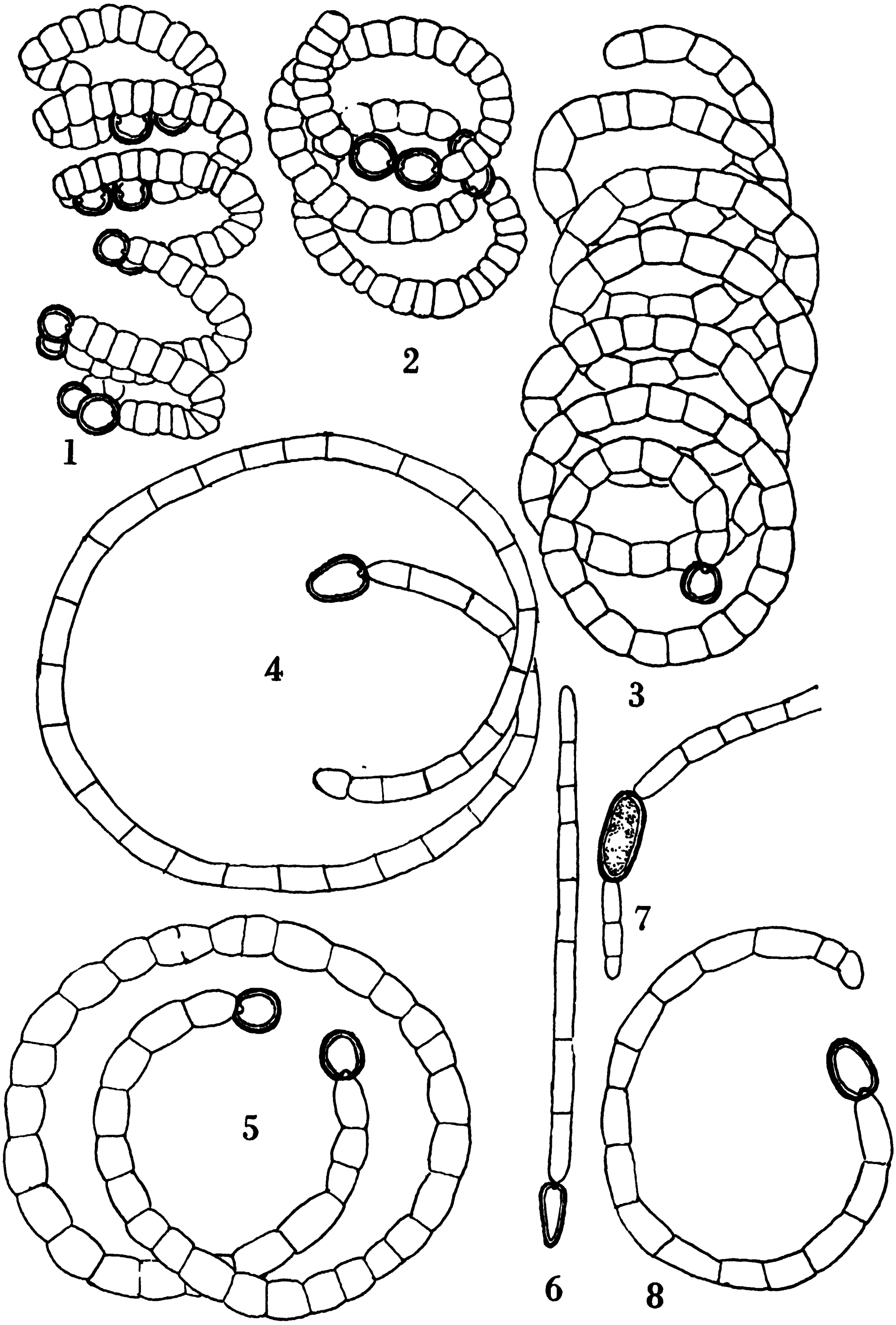

PLATE 63, Figs. 1–8.

1, 2. *Anabaenopsis arnoldii* v. *indica*. Ramanathan; 3, 5. *A. circularis* (West) Wolosz. et Miller v. *javanica* Wolosz.; 4, 8. *A. tanganyikae* (G. S. West) Wolosz. et Miller; 6, 7. *A. raciborskii* Wolosz. (all Orig.).

slightly rounded between the cells, cells usually broader than long, but distinctly longer just before division, cells 7.6–(9.5)–11.4 μ broad and 5.7–(7.6)–9.5 μ long, contents blue-green in colour, and slightly granular with a few pseudo-vacuoles; heterocysts intercalary or terminal, origin of the heterocysts always intercalary in pairs, by the development of two cells derived by an unequal division of two adjoining vegetative cells; heterocysts spherical, 9.5–(13.3)–17.1 μ in diameter, contents pale blue-green in colour, wall fairly thick with a distinct basal granule at one or even at both ends; spores ellipsoidal in shape and are 13.3–(15.2)–19.0 μ broad, and 17.1–(19.0)–22.8 μ long, spore-wall very thick and faintly striated, contents highly granular and greyish green in colour, multiplication by fragmentation of the trichome, usually between a pair of intercalary heterocysts.

Forming a water bloom in the aestuarine region of the River Cooum, at Madras (Ramanathan, *loc. cit.*); in a number of stagnant ponds, Madras ( ! )

## SPECIES INCERTA SEDIS

### **Anabaenopsis raciborskii** Wolosz.

Das Phytoplankton einiger javanischer seen, Bull. Internat. Acad. Sci. Cracovie, B, 6: 684, fig. 10, 1913; Geitler, Kryptogamenflora, 808, fig. 518, 1932.

Pl. 63, Figs. 6, 7

Filaments short, straight, seldom spirally coiled with 1–2½ spirals up to 200 μ long, mostly shorter, not constricted at the cross-walls, with a heterocyst at either end; cells cylindrical, 2.5–4 μ broad, as long as or 2–4 times longer, without gas-vacuoles; heterocysts 2–2.5 μ broad, 5–7 μ long, long-spherical; spores not known.

Plankton in lakes, Rangoon in Burma (Skuja, 1947, 40) and in a tank at Salem ( ! )

Spores have been observed in the Salem material. They were formed singly and away from the heterocysts, though not in the very middle of the trichome. The spores are generally long ellipsoidal (3–5.2 μ × 9.2–13 μ).

This species will have to be removed to the genus *Anabaena*, if Ramanathan's suggestion is to be followed.

Prescott, G. W., and Ted. F. Andrews (A new species of *Anabaenopsis* in a Kansas lake with notes on limnology, Hydrobiologia, 7: 60–63, 1954) describe a new species of *Anabaenopsis*, *A. seriata* Prescott, which resembles *Anabaenopsis raciborskii* but has spore formation in series formed adjacent to the heterocysts (*see* also *Cylindrospermum doryphorum* Bruhl and Biswas).

## APHANIZOMENON Morren

Histoire d'un genre nouveau de la tribu des Confervées, nomme par l'auteur *Aphanizomenon,* Mém. de l'Acad. roy. Belg., 11: 11, 1838; Bornet and Flahault, Revision des Nostocacées hétérocystées, 214, 1888.

Trichomes without sheath, more or less straight, forming feathery, plate-like or spindle-shaped bundles; cells elongate, at the ends attenuated; heterocysts intercalary; spores single, away from the heterocyst.

Type species: *A. incurvum* Morren.

Geitler (1942) proposes *A. flos-aquae* (L.) Ralfs (Ann. Mag. Nat. Hist., 5: 340, 1850) (*Byssus flos-aquae* L., *Limmochlide flos-aquae* K.) as the lectotype as *A. incurvum* Morren is not identifiable.

Germination of the spores has been described by Rose (Notes on the life-history of *Aphanizomenon flos-aquae,* Univ. Iowa Stud., Nat. Hist., 16: 129–40, 1934). The spores germinate only after a resting period.

### Aphanizomenon flos-aquae (Linn.) Ralfs ex Born. et Flah.

Ralfs, on the Nostochineae. Ann. Mag. Nat. Hist., 5: 340, pl. 9, fig. 6, 1850: Bornet and Flahault, Revision des Nostocacées hétérocystées, 241, 1888; Forti in De Toni, Sylloge Algarum, 5: 468, 1907; Geitler, Kryptogamenflora, 824, fig. 524, 1932; Frémy, Cyano. cotes d'Eur., 187, pl. 62, fig. 2, 1933.

Trichomes in a bundle, seldom single, straight or bent; cells 5–6 μ broad, 5–15 μ long, up to 10 times as long as broad in the terminal portions, with gas-vacuoles; heterocysts nearly cylindrical, 5–7 μ broad and 7–20 μ long; spores cylindrical, with rounded ends, 6–8 μ broad, 60–80 μ long, epispore smooth and hyaline.

Freshwater algae, N. India (Turner see Forti, in De Toni, 1907, 468).

Lemmermann (1910, 192) gives an account of the autecology of the species. He studied the formation of the spores and heterocysts in the alga. According to him the form in the non-heterocystous condition is often single and resembles very much an *Oscillatoria* but could be differentiated by the nature of the cells.

## CYLINDROSPERMUM Kütz.

Phyc. gene., 211, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 249, 1888.

Thallus mucilaginous, mostly dull blue-green; trichome uniformly broad, short, without sheath, but in a common mostly very delicate and often imperceptible, mucilage of thin consistency; cells cylindrical, constricted at the cross-walls; heterocysts terminal, at both ends or at one end only, sometimes intercalary; spores single, rarely in series, next to the heterocyst on one side, much bigger than the vegetative cells.

Type species: *C. stagnale* (Kütz.) Born. et Flah.

*Cylindrospermum* is believed to retain motility throughout life (Fritsch, 1945, 807). Harder (Ueber die Bewegung der Nostocacéen, Bot., 10: 177–244, 1918) has studied the motility in this genus. Other important studies in this genus are those of Thuret (Observations sur la reproduction de quelques Nostochinées, Mém. Soc. Sci. Cherbourg, 5: 19–32, 1857), Borzi (N. Giorn. bot. ital., 10: 272, 1878), Glade (Zur Kenntnis der Gattung *Cylindrospermum*, Cohn's Beitr. Biol. Pfl., 12: 295–346, 1914) and Bharadwaja (Ann. Bot., Lond., 47: 117, 1933).

Nitrogen fixation is known to occur in some species of *Cylindrospermum* (Glade, 1914, pp. 328–340; *see* also Maertens, H., Das Wachstun van Blaualgen in mineralischen Nahrlösungen, Beitr. z. Biol. d. Pfl., 12: 439–96, 1914; Singh, R. N., Indian. J. agri. Sci., 12: 743, 1942; Venkataraman, 1958).

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Spores with sculptured epispore | 2 |
| 1. | Spores with a smooth epispore | 3 |
| 2. | With papillae | 3 |
| 2. | Without papillae | 4 |
| 3. | Spores 10-15 × 20-30 (-30) μ | 1. *C. majus* (p. 360) |
| 3. | Spores 19 × 42-43 μ | 2. *C. tropicum* (p. 362) |
| 4. | Epispore wing like, radiately striated | 3. *C. alatosporum* (p. 362) |
| 4. | Epispore with needle shaped projections | 4. *C. gorakhpurense* (p. 363) |
| 5. | Spores spherical | 5. *C. sphaerica* (p. 363) |
| 5. | Spores not spherical | 6 |
| 6. | Spores cylindrical | 6. *C. stagnale* (p. 363) |
| 6. | Spores ellipsoidal | 7 |
| 7. | Spores oval, 17–18.5 μ broad | 7. *C. indentatum* (p. 364) |
| 7. | Spores not oval, narrower | 8 |
| 8. | Spores narrower than 10 μ | 11 |
| 8. | Spores broader | 9 |
| 9. | Spores 11–14 μ broad | 8. *C. licheniforme* (p. 366) |
| 9. | Spores narrower | 10 |
| 10. | Spores 9–12 μ broad, 10–20 μ long | 9. *C. muscicola* (p. 366) |
| 10. | Spores 8-13 μ broad, 12–32.5 μ long | 10. *C. michailovskoense* (p. 368) |
| 11. | Spores 4–6 μ broad, 8–12 μ long | 11. *C. doryphorum* (p. 368) |
| 11. | Spores 8.8–9 μ broad, 15–18.5 μ long | 12. *C. indicum* (p. 369) |

### 1. **Cylindrospermum majus** Kützing ex Born. et Flah.

Kützing, Phyc. gene., 212, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 252, 1888; Forti in De Toni, Sylloge Algarum, 5:

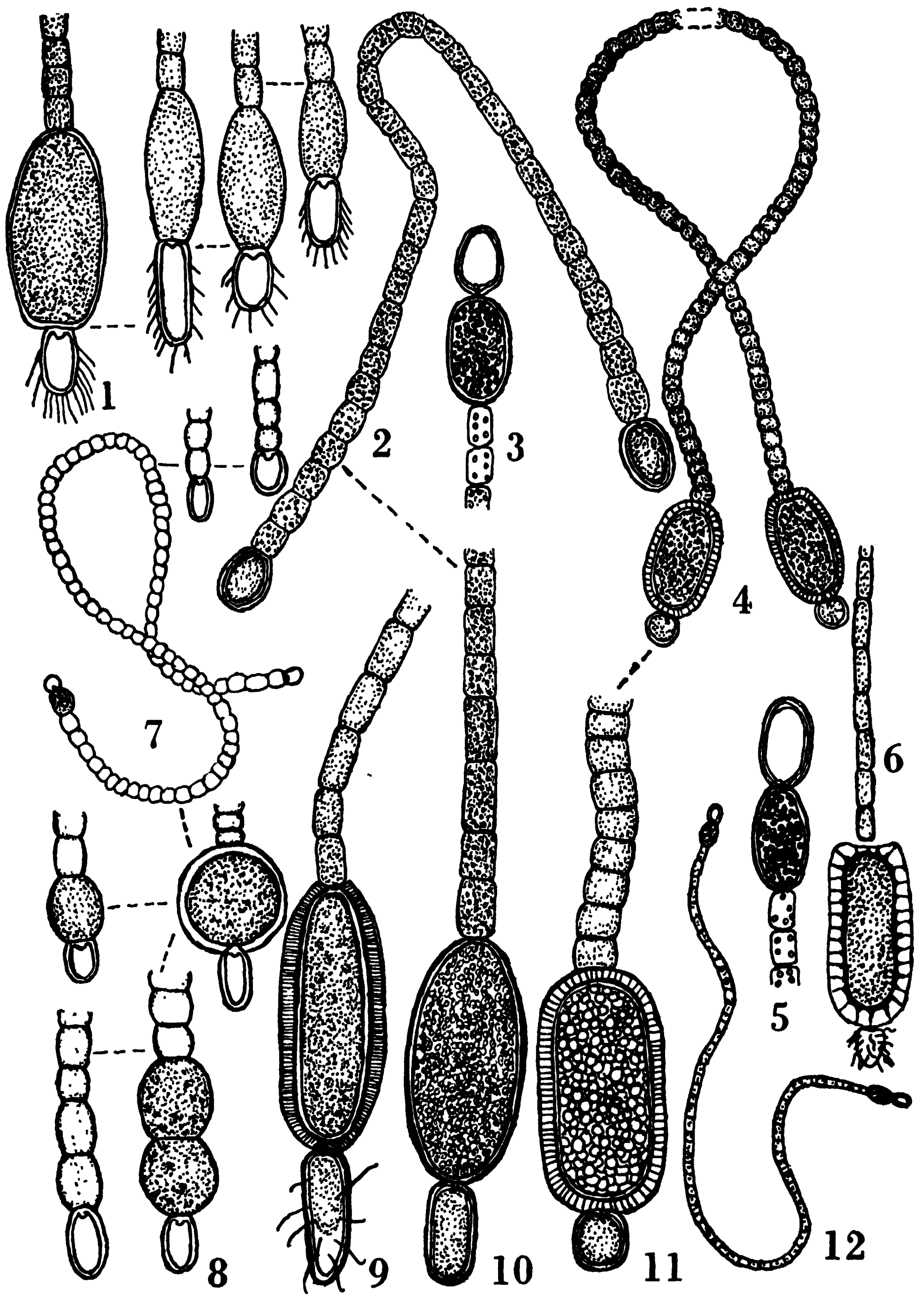

PLATE 64, Figs. 1–12.

1. *Cylindrospermum stagnale* f. *variabilis* Prasad (after Prasad); 2, 10. *Cyl. muscicola* v. *longispora* Dixit (after Dixit); 3, 5, 12. *Cyl. muscicola* v. *kashmiriensis* Bharadw. (after Bharadwaja); 4, 11. *Cyl. indicum* Rao, C. B. (after Rao, C. B.); 6. *Cyl. stagnale* f. *sporolimbata* Frémy (after Frémy); 7, 8. *Cyl. sphaerica* Prasad (after Prasad); 9. *Cyl. alatosporum* Fritsch (Orig.).

474, 1907; Frémy, Myxo. d'Afr. équat. franc., 378, fig. 315, 1929; Geitler, Kryptogamenflora, 815, fig. 520b, 1932.

Pl. 80, Fig. 1

Thallus expanded, mucilaginous, blackish green; trichome 4–5 μ broad, constricted at the cross-walls, light blue-green; cells cylindrical, 5–6 μ long; heterocysts oblong, somewhat broader than the trichome, up to about 10 μ long; spores ellipsoidal, 10–15 μ broad, 20–30(–38) μ long, epispore brownish with distinct papillae.

On moist soil and in lakes, Lahore (Ghose, 1911, 11; Singh, H. D., 1933, 106); Rangoon (Skuja, 1949, 40).

Lemmermann (Kryptogamenflora der Mark Brandenburg, 3: 194, 1910) gives the dimensions of the cells as 3–5 μ broad and 3–6 μ long.

### 2. **Cylindrospermum tropicum** W. et G. S. West

Trans. Linn. Soc., Lond., Bot., ser. 2, 6 (3): 203, 1902; Geitler, Kryptogamenflora, 817, 1932.

Trichome 3 μ broad, pale blue-green, constricted at the cross-walls; cells cylindrical, 7.5–9 μ long; heterocysts broadly ellipsoidal, 5.8–6.5 μ broad and 8 μ long; spores single, 19 μ broad, 42–43 μ long, long-ellipsoidal, with brownish papillose epispore.

In paddy-fields between Kosgoda and Urahaighasmashendai, Ceylon (West et West, *loc. cit.*).

### 3. **Cylindrospermum alatosporum** Fritsch

Contributions to our knowledge of the freshwater Algae of South Africa, II, Ann. South Afr. Mus., 9: 587, fig. 37, d, h, 1918: Geitler, Kryptogamenflora, 817, fig. 521, 1932.

Pl. 64, Fig. 9

Thallus thin, blue-green, trichomes nearly parallel or closely arranged, long, 3.5–4 μ broad; cells barrel-shaped, as long as broad or twice as long as broad; heterocysts ellipsoidal, or nearly spherical, 5 μ broad, and 7.5–10 μ long; spores mostly single, sometimes in a row, with a thick yellowish inner wall, and a colourless radially striated, wing-like in optical view, outer wall truncated at the apex, without the outer wall, 9–11 μ and with the outer wall 10–21 μ broad and 20–30 μ long.

On dripping rocks, Kunnakudi ( ! )

The Kunnakudi alga is a narrower form (Trichome 2.6–3.9 μ broad, heterocysts 3.9–5.2 μ broad, and spores with outer wall 9.2–11.8 μ broad and 19.7–29.6 μ long).

4. **Cylindrospermum gorakhpurense** Singh, R. N.

The Myxophyceae of the United Provinces—IV, Proc. Indian Acad. Sci., B, 9: 65, fig. 1D, 1939.

Pl. 74, Fig. 4

Trichomes blue-green, single, with deep constrictions at the joints, 3.5–5 μ broad; cells cylindrical 7–16.5 μ long; heterocysts almost ellipsoidal one at each end of the trichome, spores ellipsoidal with rounded apex, 6–7.8 μ broad, and 13.2–16.5 μ long, spores sub-terminal at either end of the trichome, with a thick yellowish brown outer membrane provided with a delicate needle-shaped projections, 13.2–20 μ broad and 26.4–33 μ long, without exospore 13.2–14 μ broad.

On moist soil; in a paddy-field, at Gorakhpur (Singh, R. N., 1939b, 65; 1942d, 743).

5. **Cylindrospermum sphaerica** Prasad, B. N.

Some Nostocaceae from Uttar Pradesh, J. Indian bot. Soc., 31: 358, figs. 1–4, 1952.

Pl. 64, Figs. 7, 8

Plant mass soft, mucilaginous, pale-brown, and forming a mat; trichome single, curved, often entangled with each other, 4.8–5.6 μ broad; cells barrel-shaped, 4–8 μ long, constricted at the septa; heterocysts subconical to ellipsoidal, rounded at the distal ends, one at each end of the trichome, 4.8–5.6 μ broad and 7.2–11.2 μ long; spores spherical, 16–19.2 μ broad, sub-terminal, at both ends of the trichome, formed singly, occasionally in pairs, the subterminal ones maturing first, thick brown, smooth golden brown exospore and thin, smooth and hyaline endospore.

On soil submerged by water, River Barna, Benaras (Prasad, *loc. cit.*).

6. **Cylindrospermum stagnale** (Kütz.) Born. et Flah.

Revision des Nostocacées hétérocystées, 250, 1888; Forti in De Toni, Sylloge Algarum, 5: 472, 1907; Frémy, Myxo. d'Afr. équat. franc., 375, fig. 311, 1929; Geitler, Kryptogamenflora der Mark Brandenburg, 819, fig. 520c, 1932).

= *Anabaena stagnalis* Kütz., Phyc. gene., 210, 1843.

= *Cylindrospermum macrospermum* Kützing, Phyc. germ, 173, 1845.

Pl. 65, Fig. 9

Thallus floccose, expanded, attached or free-floating, blue-green; trichomes 3.8–4.5 μ broad, constricted at the cross-walls; cells nearly quadrate, or cylindrical, and often 3–4 times as long; heterocysts subspherical or oblong, 6–7 μ broad, 7–16 μ long; spores cylindrical with rounded ends, 10–16 μ broad and 32–40 μ long, with smooth yellowish brown outer layer.

On a moist soil and in stagnant and floating waters.—Hlein River near Byn-dor-Eng and Khyounggyi on the Irrawaddy, in Kadeng Choung near Natmadhi, in Burma (Zeller, 1873b, 180, 181; Theobald, 1882, 22, 23); Ferguson's in Ceylon Algae and Planktonic in Mahakeki-rawa at Kekirawa in Ceylon (Murray, 1887, 44; Craw, 1923b, 143); on soil, Lahore in Pakistan (Ghose, 1924, 341); Freshwater Algae, Saharanpur Dist. in U.P. (Randhawa, 1936a, 405); in the river Moosi and Mir Alam tank, Hyderabad (Ghousiddin, 1936, 150) and Shembaganur in Madras State (Frémy, 1942, 22).

### f. **sporolimbata** Frémy

Cyanophycées de l'Inde méridionale, Blumea, suppl. II, 36, fig. 10, 1942.

Pl. 64, Fig. 6

Spore ornamented 1.5–2.5 μ broad, transversely striated, at first hyaline later yellowish brown.

Among other algae in stagnant waters, Shembaganur in Madras State (Frémy, *loc. cit.*).

### f. **variabilis** Prasad, B. N.

Some Nostocaceae from Uttar Pradesh, J. Indian bot. Soc., 31: 358, figs. 5–8, 1952.

Pl. 64, Fig. 1

Plant mass soft, dense, mucilaginous, light blue-green, forming a mat; trichomes single, blue-green, often entangled with each other, 4–4.8 μ broad, cylindrical or quadratic, 6.5–8 μ long, slightly constricted at the septa, heterocysts at both ends of filaments, varying in shape, narrowly cylindrical, subelliptical or almost ellipsoidal, 5.6–6.4 μ broad and 9.6–16 μ long, with elongate bacteria attached; spores elongate, subcylindrical, broader at the heterocyst ends and flattened slightly at the sides, formed singly, subterminally with a thick hyaline exospore, and a thin colourless endospore, 16.4–17.6 μ broad and 29–32 μ long.

On soil submerged with water, River Barna, Banares (Prasad, *loc. cit.*).

### 7. **Cylindrospermum indentatum** West, G. S.

J. Bot., Lond., 47: 6, 1909; Geitler, Kryptogamenflora, 820, fig. 523a, 1932.

Thallus irregular, small, gelatinous, 2–3.5 mm. diam., trichome 4.5–5 μ broad; cells nearly quadrate or longer than broad, 3/4–11/2 times longer

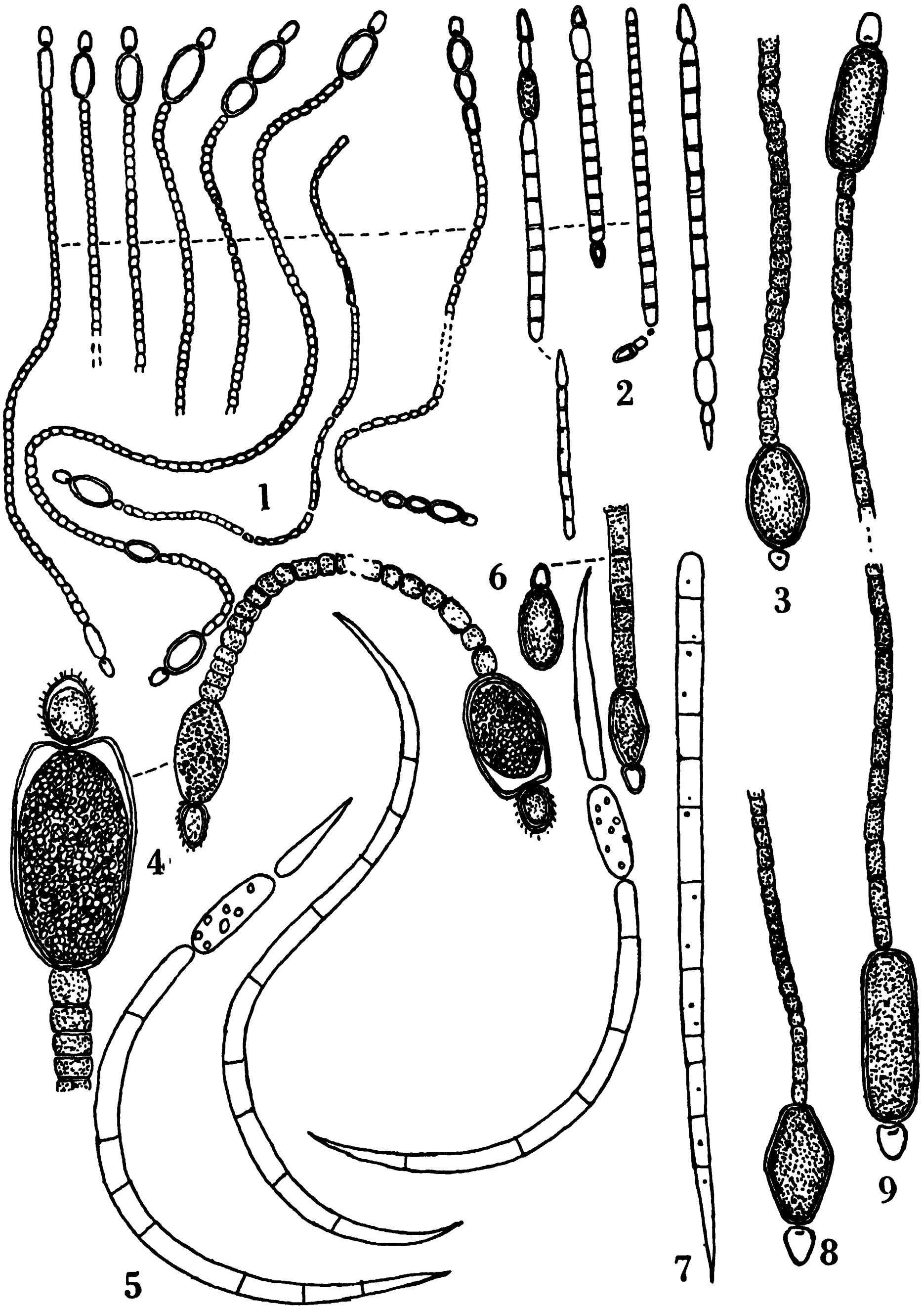

PLATE 65, Figs. 1–9.

1. *Cylindrospermum michailovskoense* Elenkin (after Kossinskaja); 2. *Cyl. doryphorum* Bruhl et Biswas (after Bruhl & Biswas); 3. *Cyl. muscicola* Kütz. (after Frémy); 4. *Cyl. indentatum* West, G. S. v. *major* Rao, C. S. (after Rao, C. S.); 6. *Cyl.*; 8. *Cyl. licheniforme* (Bory) Kütz. (after Frémy); 9. *Cyl. stagnale* (Kütz.) Born. et Flah. (after Frémy); 5, 7. *Raphidiopsis curvata* Fritsch et Rich (after Holsinger).

than broad; heterocysts long ellipsoidal, 5.8–6.5 μ broad and 9–11.5 μ long; spores single, oval-ellipsoidal, rounded on the heterocyst side, truncated on the other side, and slightly concave, 17.5–18.5 μ broad and 34–36 μ long, epispore smooth.

Type not recorded.

f. **major** Rao, C. S.

The Myxophyceae of the Bihar Province, India I, Proc. Indian Acad. Sci., 13, 9(3): 147, fig. 1, M, N, 1939.

Pl. 65, Fig. 4

Trichomes broader than in the type, 5.5–6 μ broad; cells 5.6–12 μ long; heterocysts at both ends, 7–10 μ broad, 11–16 μ long; spores subterminal at both ends, 16–18 μ broad, 30–40 μ long.

Floating in a canal, Muzaffarpur, Bihar (Rao, C. S., *loc. cit.*).

8. **Cylindrospermum licheniforme** Kütz ex Born. et Flah.

Kützing, Diagnosen und Bemerkungen etc., Bot. Zeitung, 5: 197, 1847; Tab. Phycologicae, 1: 53, pl. 98, fig. 6, 1849; Born. et Flah., Revision des Nostocacées hétérocystées, 253, 1888; Forti in De Toni, Sylloge Algarum, 5: 476, 1907; Frémy, Myxo. d'Afr. équat. franc., 376, fig. 312, 1929; Geitler, Kryptogamenflora, 821, fig. 520e, 1932.

= *Cylindrospermum spirale* Kütz., Phyc. gene., 212, 1843.

Pl. 65, Fig. 8

Thallus mucilaginous, orbicular, confluent, later more or less expanded, blackish green; trichome (2.5–) 4.2 μ broad, constricted at the cross-walls, pale blue-green; cells quadrate to cylindrical, 4–5 μ long; heterocysts oblong, (4–) 5–6 μ broad, 7–12 μ long; spores oblong to ventricose elliptic, 12–14 μ broad, 20–30 (–38) μ long, with a smooth reddish brown epispore.

On soils and in stagnant or running waters — Calcutta (Martens, 1871a, 171; also Prain, 1905, 334), Simla (Ghose, 1924, 341), River Barna near Benaras (Prasad, 1952, 358).

Glade (1914) distinguished two forms in cultures which differed in the dimensions. Lemmermann (1910, p. 195) himself gives the dimensions of the trichome as 2.5–4.2 μ. Glade's forms vary from 3.4 to 4.8 μ in breadth (*see* also Geitler, 1932, p. 821). It seems best to accept Lemmermann's expanded concept of the species.

9. **Cylindrospermum musicola** Kützing ex Born. et Flah.

Kützing, Phyc. germ., 173, 1845: Tab. phycologicae, 1: 53, pl. 98, fig. 1, 1849; Bornet et Flahault, Revision des Nostocacées hétérocystées, 254, 1888;

Forti in De Toni, Sylloge Algarum, 5: 477, 1907; Frémy, Myxo. d.Afr. équat. franc., 376, fig. 313, 1929; Geitler, Kryptogamenflora, 822, fig. 520d, 1932.

Pl. 65, Fig. 3

Thallus expanded, mucilaginous, blackish-green; trichomes 3–4.7 μ broad, constricted at the cross-walls, light blue-green; cells 4 (–5) μ long, cylindrical, or nearly quadrate; heterocysts oblong, 4 (–5) μ broad, 5–7 μ long; spores oval, 9–12 μ broad, 10–20 μ long, epispore smooth, yellowish brown.

On damp soil and in stagnant water — Rangoon in Burma (Ghose, 1926, 249; 1927e, 82), wheat fields, N. India (Randhawa, 1936C, 38), Benaras (Rao, C. B., 1937b, 358), Polamur in Andhra (Rao, C. B., 1938a, 88), Puri in Orissa (Rao, C. B., 1938b, 162).

Singh, (An investigation into the Algal flora of paddy field soils of U.P.—I, Indian J. Agri. Sci., 9: 59, 1939a.) describes a form.

Cells 3.3–4.6 μ broad, 4.5 6.6 μ long; heterocysts 3.3–5 μ broad and 6.6–7.8 μ long; spores 9.2–12.6 μ broad and 13.2–20.3 μ long.

In cultures of paddy field soil from Mirzapur, Basti, Gorakhpur and Benaras Districts (Singh, R. N., *loc. cit.*).

### Var. **longispora** Dixit

The Myxophyceae of Bombay Province—I, Proc. Indian Acad. Sci., B, 3: 100, fig. 3A, B, 1936.

Pl. 64, Figs. 2, 10

Trichome 3.7–4 μ broad, 4.5–7.5 μ long; heterocysts 5–6 μ broad and 7.5–10 μ long; spores 7.5–12.5 μ broad and 21.5–31.5 μ long.

On water-logged soil in rice fields, Mandapeshwar, Borivali (Dixit, 1936, 100).

### Var. **kashmiriensis** Bharadwaja

Contributions to our knowledge of Myxophyceae of India, Ann. Bot., Lond., 47: 117, figs. 1–2, 1933a.

Pl. 64, Figs. 3, 5, 12

Thallus thin, velvety, shining, bluish-green, irregular layer, very soft and mucilaginous, attached, up to 1.5 cm. wide; trichomes in the upper part of the thallus more or less straight and parallel, in the lower parts irregularly bent, and more or less entangled, 125 to 200 μ long, slightly constricted at the joints; cells barrel-shaped, twice as long as broad, 2.6–3.9 μ broad, and 2.6–8.4 μ long, septa indistinct; heterocysts one at either end in mature filaments or only at one end in younger ones, oval or ellipsoidal, 3.9–5.2 μ broad and 5.2–10.5 μ long, intercalary heterocysts single or in pairs, shorter or longer than vegetative cells; spores adjoining to the terminal heterocysts, barrel-shaped or ellipsoidal, 5.2–7.8 μ broad and 9.4–13.6 μ long, epispore thick, smooth and brownish.

On *Myriophyllum* in a shallow pond, Srinagar, Kashmir (Bharadwaja, *loc. cit.*).

Var. **kashmiriensis** Bharadwaja, forma Singh, V. P.

On a collection of algae from Chamba State (Punjab) I, Proc. Indian Acad. Sci., B. 14 (3) : 252, 1941.

Cells 3.8–4 μ broad, 3.8–4.5 μ long; heterocysts 4.6–5.7 μ broad and up to 7.7 μ long; spores 5.7–7.7 μ broad and 9.4–23 μ long.

In a stagnant roadside ditch, on Chil to Chamba road, Punjab (Singh, *loc. cit*).

### 10. **Cylindrospermum michailovskoense** Elenkin

Neue selt. od. interess. Art. u. Form. d. Alg., in Mitt. Russl., II, Bull. Jardin Imp. Pierre le Gr., 11 : 162, 1911; Kossinskaja, Bull. Jardin Bot. princ. d. l'URSS, 29, 119, pl. 1, fig. 3, 1930; Elenkin, Monogr. Alg. Cyano., pars spec., 1 : 830, fig. 242, 1938.

Pl. 65, Fig. 1

Thallus expanded, blue-green; trichome pale blue-green, mostly bent, sometimes straight, aggregated; cells quadrate or mostly cylindrical, more or less constricted at the cross-walls, 3.5–5 μ broad, 6–7 μ long; heterocyst nearly spherical, oblong, 5–6 μ broad, 7–8 μ long; spores single, broadly ellipsoidal, or oblong, 8–13 μ broad, 12–32.6 μ long, epispore colourless.

On the sides of reservoirs, N. India (Randhawa, 1936c, 44).

Geitler (1932, 823) does not consider this species distinct from *Cylindrospermum muscicola*. Elenkin (1938, 830) refers to further investigations by Kossinskaja (*loc. cit.*) and considers that this species is quite distinct from *Cyl. muscicola*.

### 11. **Cylindrospermum doryphorum** Bruhl et Biswas

On a new species of *Cylindrospermum* from Bengal — *C. doryphorum* Bruhl et Biswas, J. and Proc. Asiatic Soc., Bengal, N. S., 18 (10) : 577, fig. 1922.

Pl. 65, Fig. 2

Thallus floating, cloud-like, indefinite outline, green; trichome not at all or slightly constricted, 2–4 μ broad, dissepiments hyaline, apices attenuated, subacute; cells cylindrical, 4–8 μ long; heterocyst at either end, pale blue-green, lanceolate, sometimes one only or absent after fragmentation, 2–4 μ broad, and 4–8 μ long; spores scarce nearly always single, rarely in pairs, adjacent to the terminal heterocysts, sometimes separated by one or few vegetative cells, densely or coarsely granular, wall firm, hyaline, smooth, 4–6 μ broad and 8–12 μ long.

In stagnant waters, Bengal (Bruhl et Biswas, *loc. cit.,* 1932d, 330); Setapak, Kuala Lumpur, Malaya (Biswas, 1929, 410).

Geitler (1932, p. 814) and Bharadwaja (1933a, p. 122) suggested excluding this species.

G. W. Prescott and T. F. Andrews describe *Anabaenopsis seriata* Prescott, which in many aspects has close resemblance to *Cylindrospermum doryphorum.*— Trichomes solitary or entangled, short, straight or slightly curved, up to 80 μ in length, tapering at one or at both ends, never coiled; cells cylindrical, not constricted at the cross-walls, cell-contents blue-green, finely and densely granular; heterocysts conical, terminal at one or rarely at both ends of the trichome, 3 μ in diameter, 4.6–5 μ long; akinetes oval to cylindrical, solitary or in terminal series (2–5) adjacent to the heterocysts, 3–3.5 μ in diameter, 9–16 μ long, contents coarsely granular; vegetative cells 2.5–2.8 μ in diameter, 7.5–10 μ long.

12. **Cylindrospermum indicum** Rao, C. B., orth. mut. De Toni

Rao, C. B., The Myxophyceae of the United Provinces, India-II, Proc. Indian Acad. Sci., B., 3: 169, fig. 2, D, E, 1936.

Pl. 64, Figs. 4, 11

Trichome single with deep constrictions at the joints, 3.7 μ broad, dark blue-green; cells almost quadrate, or more or less barrel-shaped, 3–4.5 μ long; heterocysts spherical, subspherical, subconical, or ellipsoidal, sometimes cylindrical, one at each end of the trichome, 2.8–5.8 μ broad and 3–7.6 μ long; spores almost ellipsoidal, sometimes cylindrical, subterminal at either end of the trichome, with a thick yellowish brown outer membrane possessing a smooth outer margin and exhibiting faint lines running across in optical section, without membrane 8.8–9 μ broad and with membrane 10–12 μ broad, without membrane 15–18.5 μ long and with membrane 18–22 μ long.

In earthenware water pans in a green-house, Benaras (Rao, C. B., *loc. cit.*).

According to Frémy (1942) this may be a form of *C. muscicola.*

## SPECIES INSERTAE SEDIS

### Cylindrospermum humicola Kützing

Phyc. gene., 212, 1843; Tab. phycologicae, 1: pl. 99, fig. 1, 1849; Forti in De Toni, Sylloge Algarum, 5: 478, 1907.

Thallus thin, greenish to blue-green, disciform expanded, opaque; trichomes flexuous-curved, apex attentuated, light blue-green, densely intricate; cells spherical, 5 μ broad, elliptical or elongate, cylindrical; heterocysts globose, nearly double as broad as the cells; spores ellipsoidal to cylindrical, double as long as broad.

On river mud at Khyoung-gyi on the Irrawady, Burma (Zeller, 1873b, 131; Theobald, 1883, 22).

### **Cylindrospermum bengalense** Biswas

Road slimes of Calcutta, J. Dept. Sci., Calcutta Univ., 7: 7, 1925.

Stratum expanded, thin, membranaceous; trichomes 3–4 μ in width, elongated, more or less fragile, sinuous, constricted at the joints but not torulose; intricate; cells often rectangular or oblong, not granulated at the partition walls, 4–6 μ in length; heterocysts terminal never at both ends, lance-shaped, flat at the base, subacute at the apices, 6–8 μ by 3–4 μ at the broadest part; spores elliptical or oblong, 12–24 μ by 6–10 μ; epispore smooth hyaline; contents coarsely granular, blue-green.

In road slimes, Calcutta (Biswas, *loc. cit.*).

## WOLLEA Born. et Flah.

Revision des Nostocacées hétérocystées, 223, 1888.

Thallus tubular, cylindrical, soft; filaments suberect, parallel, to slightly curved, agglutinated; sheath confluent; heterocysts intercalary; spores in series continuous with the heterocysts or remote from it.

Type species: *W. saccata* (Wollea) Born. et Flah.

The genus is essentially based on the form of the thallus and Bornet and Flahault (*loc. cit.*) compare it to that of *Tetraspora lubrica.*

For a long time only a single species was known. Recently Singh, R. N. (1942) described a second species, *W. bharadwajae* from Benaras and Gorakhpur in India. He studied the autecology of this form. According to him the genus would include five species besides the type, *W. vaginicola* = (*Anabaena vaginicola,* Fritsch and Rich.), *W. cylindrica* (= *Anabaenothinx cylindrica* Ghose and Randhawa (Pl. 13, Fig. 4), = *Anabaena vaginicola* forma?), *W. bharadwajae, W. epiphytica* (= *Anabaenothrix epiphytica* Ghose and Randhawa (Pl. 13, Fig. 3), (= *Anabaena vaginicola* var.?), *W. ambigua* (= *Anabaena ambigua* Rao). Only *W. bharadwajae* can undoubtedly go in here. Inclusion of the other four in *Anabaena* is more appropriate.

Singh (1942, p. 596) has described the germination of the spores in *W. bharadwajae.*

Only one species known from the region.

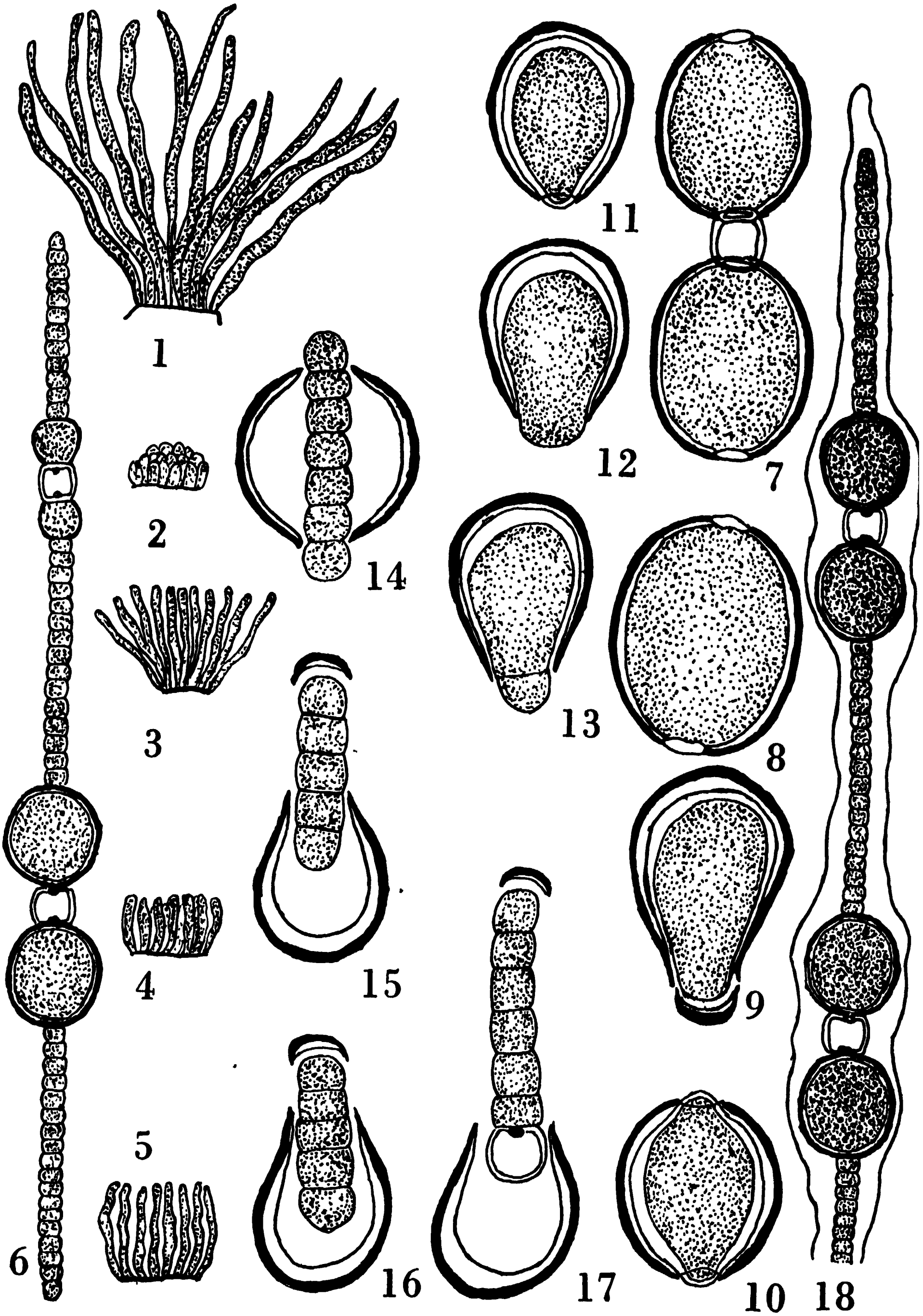

PLATE 66, Figs. 1–18.

*Wollea bharadwajae* Singh, R. N. ;1–5. Habit of the thallus, 9–17. germination of akinetes. (after Singh).

### **Wollea bharadwajae** Singh, R. N.

*Wollea bharadwajae* sp. nov., and its Autecology, Ann. Bot., Lond., n.a. 6: 593–606, 1942.

Pl. 66

Thallus first club-shaped vesicles, later more or less cylindrical, attached, later free-floating, 4–5 cm. long and 2–2.5 mm broad; trichomes straight, parallel, sometimes curved, up to 1 mm long, deeply constricted at the cross-walls, attenuated; cells barrel-shaped, 3.5–4.8 μ broad and 2.5–3.5 μ long, apical cell conical, deep blue-green; heterocysts pale blue-green; intercalary at regular intervals, barrel-shaped with flat ends, larger than the vegetative cells; 5.8–7.0 μ broad and 6.0–7.5 μ long; spores formed at the end of the period, formed singly on either side of a heterocyst, spherical or subspherical, mature ones yellowish-green, exospore thick dark-brown, endospore thin, hyaline.

On submerged soil in the littoral zone of ponds, Benaras and Saruan Jhil in Gorakhpur District, and Delhi (Singh, R. N., *loc. cit.*; G. S. Venkataraman, 1957); Paddy-field, Tirupati ( !) in Andhra and in rock pools about waterfalls at Rahatgarh, Madhya Pradesh.

The Tirupati alga has trichomes which are broader (2.6–5.2 μ broad).

Prasad, (Some Nostocaceae from U.P., J. Indian bot. Soc., 31: 360, figs. 9–13, 1952.) describes a form.

Pl. 73, Fig. 1

Trichomes 5–5.8 μ broad; cells 4.8–6.4 μ long; heterocysts 6–7 μ broad; spores 10–12 μ broad and 12–12.8 μ long, formed in rows of two or three on either side of the heterocyst.

Floating in water, River Barna, Benaras (Prasad, B. N., *loc. cit.*).

Prasad collected the alga only in the free-floating condition. Further *W. bharadwajae* is differentiated from *W. saccata* in the smaller colonies, vegetative cells and heterocysts being barrel-shaped, slightly tapering trichome ends and in the subspherical spores which are formed singly on either side of the heterocysts. Prasad's form differs from the type in having broader trichomes and in the smaller spores which are formed two or three together on either side of the heterocyst. In these characters Prasad's form resembles *W. saccata* more than *W. bharadwajae.*

## **NOSTOC** Vaucher

Histoire des Confervées d'eau douce, 203, 1803; Bornet and Flahault, Revision des Nostocacées hétérocystées, 181, 1888.

Thallus mucilaginous, gelatinous or coriaceous, first globose to oblong, later globose, foliose, filiform, bullose, solid or hollow, free or attached, the periphery dense and darkly coloured; filaments flexuous, curved or entangled; sheath sometimes distinct, generally diffluent; trichome torulose; cells depressed, spherical, barrel-shaped or cylindrical; heterocysts intercalary, and in young condition terminal; spores spherical, or oblong, formed centrifugally in series in between the heterocysts.

Type species: *N. commune* Vaucher.

Vaucher includes five species of which four are invalid. *Nostoc commune* Vaucher, according to Setchell and Gardner (1919, p. 92), may be recognised as the type.

Elenkin (1938) has made extensive changes in this genus. He divided *Nostoc* into four genera for all of which he proposed new names and does not retain the name *Nostoc* to any of them. He enlarges the circumscription of many species of *Nostoc*. As an example may be cited *N. linckia* Roth (= *Stratonostoc linckia* (Roth) Elenkin) in which he includes about 25 species and creates 11 forms under the species to receive some of the merged species. Similar is the case of *Nostoc commune* also.

## KEY TO THE SPECIES

1. Thallus attached, maculiform, filaments contorted ....... 1. *N. maculiforme* (p. 374)
1. Thallus not maculiform ....... 2
    2. Thallus without a firm outer layer, more or less soft and formless ....... 3
    2. Thallus wit a firm layer ....... 15
3. Trichomes very densely coiled, hardly seen 2.4–4.4 μ broad 2. *N. punctiforme* (p. 374)
3. Trichomes less densely coiled, mostly clearly visible ....... 4
    4. Thallus microscopically small ....... 5
    4. Thallus macroscopic ....... 6
5. Trichomes 2.5–3 μ broad, relatively thickly arranged ....... 3. *N. entophytum* (p. 375)
5. Trichomes 3.3–5 μ broad, loosely arranged ....... 4. *N. paludosum* (p. 375)
    6. Aquatic ....... 7
    6. Subaerial ....... 11
7. Trichomes densely arranged, coiled ....... 5. *N. linckia* (p. 377)
7. Trichomes not densely arranged ....... 8
    8. Spores spherical ....... 6. *N. piscinale* (p. 377)
    8. Spores longer than broad ....... 9
9. Cells cylindrical ....... 10
9. Cells little longer than broad ....... 7. *N. rivulare* (p. 379)
    10. Heterocysts 7–8 μ broad, spores 6–7 × 10–12 μ 8. *N. spongiaeforme* (p. 380)
    10. Heterocysts 6 μ broad, spores 6 × 8–10 μ ....... 9. *N. carneum* (p. 381)
11. Cells cylindrical ....... 10. *N. ellipsosporum* (p. 383)
11. Cells barrel-shaped, shorter or a little longer than broad ....... 12
    12. Trichomes 2.2–3 μ broad ....... 13
    12. Trichomes 3.5–5 μ broad ....... 14

| | |
|---|---|
| 13. Spores oblong | 11. *N. humifusum* (p. 384) |
| 13. Spores spherical | 12. *N. calcicola* (p. 384) |
| 14. Trichomes parallel, spores 6 × 8 μ | 13. *N. passerinianum* (p. 385) |
| 14. Trichomes with no definite mode of arrangement | 14. *N. muscorum* (p. 385) |
| 15. Subaerial | 16 |
| 15. Aquatic | 17 |
| 16. Thallus very large, flat, membranous | 15. *N. commune* (p. 387) |
| 16. Thallus small 1 mm or reaching a maximum of 1 cm, more or less spherical, trichome 5–8 μ broad | 16. *N. microscopicum* (p. 387) |
| 17. Trichomes not radially arranged | 18 |
| 17. Trichomes radially arranged | 21 |
| 18. Thallus surface wrinkled | 17. *N. verrucosum* (p. 388) |
| 18. Thallus surface smooth | 19 |
| 19. Heterocysts about 10 μ broad | 18. *N. coeruleum* (p. 388) |
| 19. Heterocysts narrower | 20 |
| 20. Adult colonies many cm in diam. | 22 |
| 20. Colonies up to 2 cm in diam. | 19. *N. hatei* (p. 389) |
| 21. Thallus attached, discoid, or ligulate | 20. *N. parmelioides* (p. 389) |
| 21. Thallus free swimming, more or less spherical | 21. *N. pruniforme* (p. 390) |
| 22. Trichomes 4–5 μ broad, thallus up to 7 cm broad | 22. *N. sphaericum* (p. 390) |
| 22. Trichomes 2–3 μ broad, thallus larger | 23. *N. amplissimum* (p. 390) |

### 1. **Nostoc maculiforme** Born. et Flah.

Revision des Nostocacées hétérocystées 189, 1888; Forti in De Toni, Sylloge Algarum, 5: 188, 1907.

Thallus flat attached, forming thin irregular blue-green spots; filaments flexuous, contorted densely packed, into loose net-like masses; sheath distinct, close; trichome 3.5–4 μ broad, cells oblong to depressed spherical; spore (immature) globose, mostly 6 μ, rarely 8 μ broad, in long catenate chains, exposure smooth, thick and fused with the sheath.

With *Enteromorpha intestinalis* near Colombo, Ceylon (Ferguson ex Born. et Flah., *loc. cit.*).

### 2. **Nostoc punctiforme** (Kütz.) Hariot

J. de Bot., 5: 31, 1891; Forti in De Toni, Sylloge Algarum, 388, 1907; Frémy, Myxo. d'Afr. équat. franc., 331, fig. 274, 1929; Geitler, Kryptogamenflora, 834, 1932.

= *Nostoc hederulae* Meneghini in Kützing, Sp. Alg., 287, 1849; Born. and Flah., Revision des Nostocacées hétérocystées, 189, 1888.

Pl. 69, Fig. 1

Thallus sub-globose up to 2 mm diam., scattered or confluent, attached; filaments flexuous, densely entangled; sheath delicate, hyaline, mucous; trichome 3–4 μ broad, cells short barrel-shaped or ellipsoidal, blue-green;

heterocysts 4–6.5 μ broad; spores subspherical, or oblong, 5–6 μ broad and 5–8 μ long, epispore thick and smooth.

Mahaluxmi, Bombay (Schmidle, 1900b, 161) with other algae in a pool in Kodaikanal ( ! ).

The Kodaikanal alga is slightly different, trichomes 2.6–3.9 (5.2) μ broad, heterocysts 2.6 μ broad, spore subspherical 3.9–6.6 μ diam.

### 3. **Nostoc entophytum** Born. et Flah.

Revision des Nostocacées hétérocystées, 190, 1888; Forti in De Toni, Sylloge Algarum, 5: 389, 1907; Geitler, Kryptogamenflora, 836, 1932; Frémy, Cyano. cotes d'Eur., 174, pl. 57, 1933.

Thallus small macroscopic inconspicuous, blue-green or yellowish, growing on aquatic plants, also in the cells or lacuna of plants; filaments densely entangled; sheaths generally distinct, hyaline later brownish; trichomes 2.5–3 μ broad, torulose; cells short barrel-shaped; heterocysts broader than the vegetative cells; spores spherical or slightly compressed, 5-6 μ broad, rarely oblong, 5–8 μ long, with brown smooth epispore.

In cultures of paddy-field soil, Goregaon near Bombay (Gonzalves and Gangla, 1949, 54).

Elenkin (1938, p. 562) includes this species under *N. paludosum* (= *Amorphonostoc paludosum* (Kütz.) Elenkin) along with *N. tenuissimum.*

### 4. **Nostoc paludosum** Kützing ex Born. et Flah.

Kützing, Tab. Phycologicae, 2: 1, pl. 1, fig. 2, 1850; Bornet et Flahault, Revision des Nostocacées hétérocystées, 191, 1888; Forti in De Toni, Sylloge Algarum, 5: 390, 1907; Frémy, Myxo. d'Afr. équat. franc., 332, fig. 275, 1929; Geitler, Kryptogamenflora, 836, fig. 528a, 1932.

Pl. 69, Fig. 2

Thallus microscopically not visible, punctiform, gelatinous; sheath broad, colourless or yellowish brown; trichomes 3–3.5 μ broad; cells as long as broad, barrel-shaped, pale blue-green; heterocysts broader than the vegetative cells; spores oval, 4–4.5 μ broad, 6–8 μ long, with smooth colourless membrane.

In rice fields, Allahabad (Mitra, 1951, 359).

Rao, (Myxophyceae of United Provinces, III, Proc. Indian Acad. Sci., B., 6: 358, 1937b.) describes a form.

Trichome 3–4 μ broad; cells 3.8–4.8 μ long; heterocysts 5.6–6.4 μ broad and 6.6–8 μ long; spores 4.6–6.4 μ broad and 6.4–10 μ long.

In the stagnant water of a crop field, Benaras (Rao, C. B., *loc. cit.*).

The form has bigger spores.

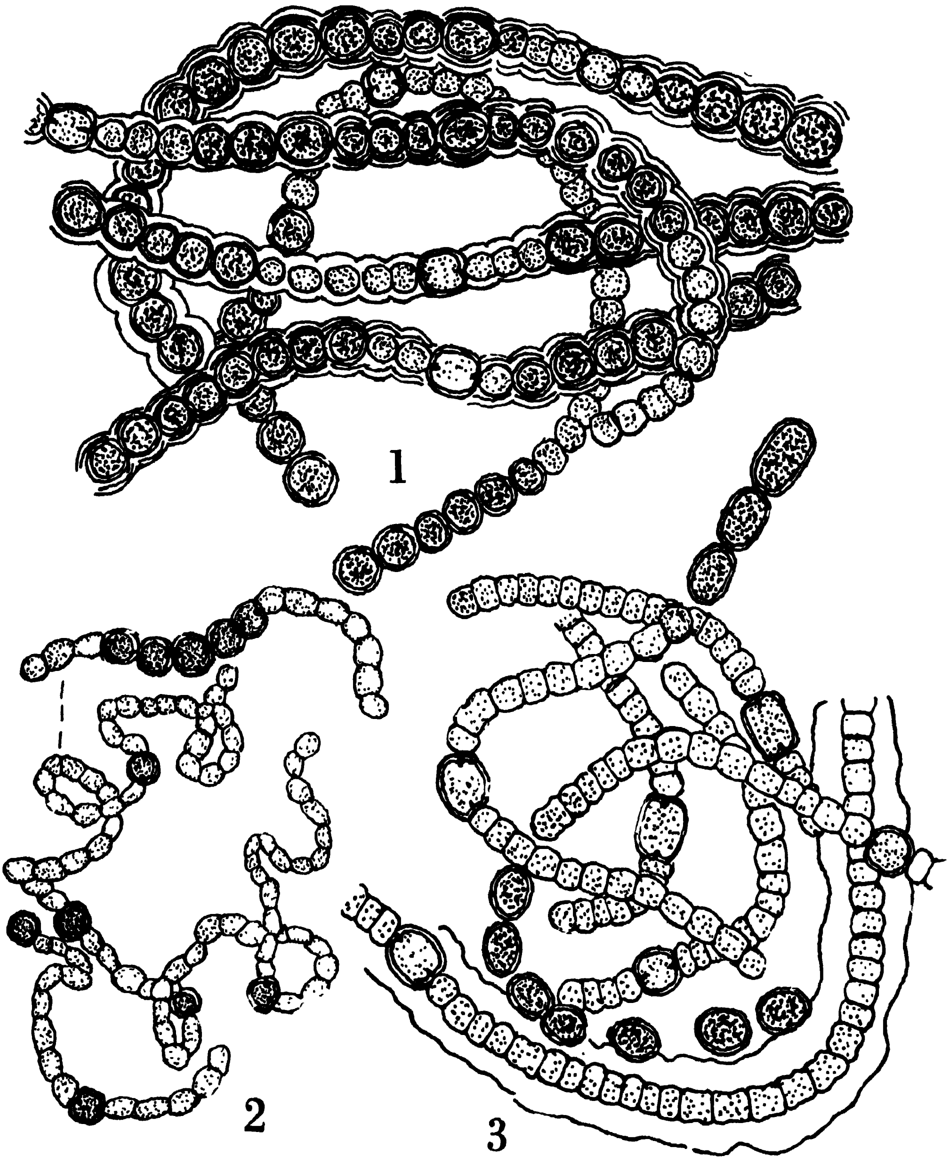

PLATE 67, Figs. 1–3.

1. *Nostoc linckia* v. *arvense* Rao, C. B. (after Rao, C. B.); 2. *N. hatei* Dixit (after Dixit); 3. *N. spongiaeforme* v. *varians* Rao, C. B. (after Rao, C. B.).

Mitra (1951, 360) mentions of a var. *major* (*nomen nudum*) from rice field soil from Allahabad and of a form from red soil from Vandalur near Madras and from wheat field soil from near Allahabad.

### 5. **Nostoc linckia** (Roth) Bornet ex Born. et Flah.

Bornet in Bornet and Thuret, Notes algologiques, II, 86, pl. 18, figs. 1–12, 1880; Born. et Flah., Revision des Nostocacées hétérocystées, 192, 1888; Forti in De Toni, Sylloge Algarum, 5: 391, 1907; Frémy, Myxo. d.Afr. équat. franc., 332, fig. 276, 1929; Geitler, Kryptogamenflora, 838, fig. 528b, 1932; Frémy, Cyano. cotes d'Eur., 175, pl. 58, fig. 1, 1933.

Thallus varying in size, sometimes punctiform, sometimes tuberculate, at first globose later irregularly expanding, torn, gelatinous, blue-green to violet, or blackish green or brown; filaments densely entangled, flexuous or highly coiled; sheath diffluent and colourless inside, distinct only in the peripheral portion; trichomes 3.5–4 μ broad, pale blue-green; cells short barrel-shaped; heterocysts subspherical; spores subspherical, 6–7 μ broad, 7–8 μ long, epispore smooth.

In cultures of paddy field soil from Thana, near Bombay (Gonzalves and Gangla, 1949, 53); on *Rhizoclonium profunda*, McPherson Lake, Allahabad (Gupta, 1956, 77); in a flower pot in the laboratory, Rangoon (Skuja, 1949, 43).

### Var. **arvense** Rao, C. B.

The Myxophyceae of United Provinces, III, Proc. Indian Acad. Sci., B, 6: 358, fig. 4A, 1937b.

Pl. 67, Fig. 1

Thallus gelatinous, expanded, presenting an uneven surface, yellowish brown to blue-green; filaments numerous, flexuous; trichomes 4–5.6 μ broad, frequently enveloped by a lamellated and yellowish brown mucilaginous sheath that follows their contour; cells spherical or barrel-shaped, 4.8–6.4 μ long; heterocysts almost spherical, 4.8–7.2 μ broad, usually not enveloped by any mucilage; spores in long chains, more or less spherical, 7–8 μ broad, outer wall brown.

On a water-logged soil in a crop field, Benaras (Rao, C. B., *loc. cit.*).

Mitra (1951, 359/360) mentions of a new variety *globispora* (*nomen nudum*).

### 6. **Nostoc piscinale** Kützing ex Born. et Flah.

Kützing, Phyc. gene. 208, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 194, 1888; Forti in De Toni, Sylloge Algarum, 5: 393,

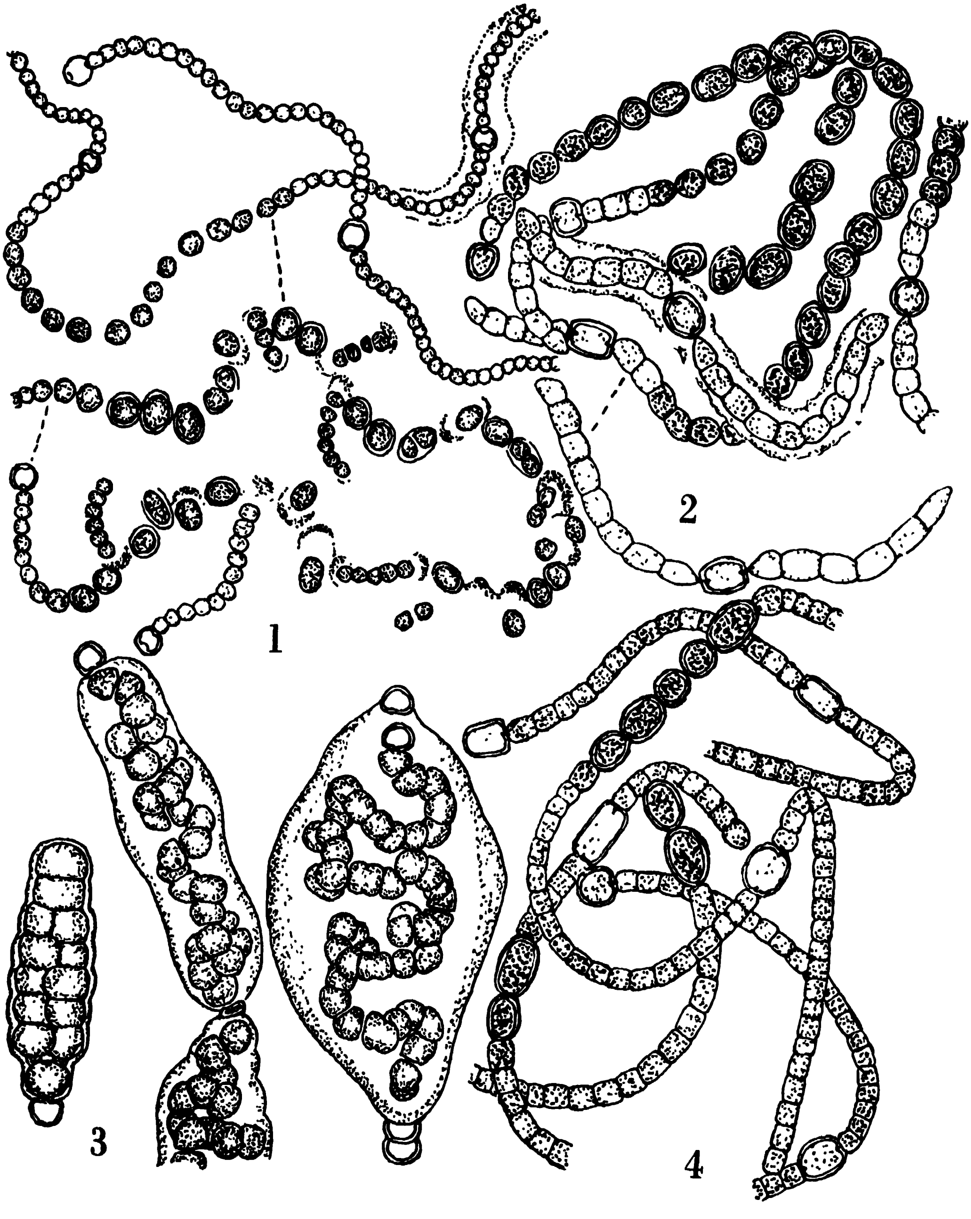

PLATE 68, Figs. 1–4.

1. *Nostoc calcicola* Bréb. (after Frémy); 2. *N. spongiaeforme* v. *tenue* Rao, C. B. (after Rao, C. B.); 3. *Nostoc commume* Vaucher, germlings. (after Geitler); 4. *N. ellipsosporum* v. *violacea* Rao, C. B. (after Rao, C. B.).

1907; Frémy, Myxo. d'Afr. équat. franc., 335, fig. 277, 1929; Geitler, Kryptogamenflora, 838, fig. 529, 1932.

Pl. 69, Fig. 3

Thallus at first globose, later bullose, or variously tuberculate, mucilaginous or gelatinous, light blue-green, olive-green to brown; filaments flexuous, loosely entangled; sheath distinct at the periphery of the thallus, brownish, diffluent in the inner portions of hyaline; trichome 3–7 µ broad; cells shorter or longer than broad up to nearly twice as long as broad; heterocysts subspherical or oblong, 4.5–6 µ broad; spores globose, 6–7 µ broad, in long chains, epispore smooth and hyaline with a sheath.

On the surface of soil, near Dadar, Bombay (Beck and Zahlbruchner, 1897, 82); among other algae in a flower tank, Khuroobag, Allahabad (Gupta, 1956, 77).

Elenkin (1938, p. 595) includes this as a form under *N. linckia* Roth ( = *Stratonostoc linckia* (Roth) Elenk.).

Rao, (The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 359, 1937b.) describes a form.

Trichome 4–6 µ broad; heterocysts 6.4–7.2 µ broad; spores 6–10 µ broad. In the stagnant water of a crop field, Benaras (Rao, *loc. cit.*)

### 7. **Nostoc rivulare** Kützing ex Born. et Flah.

Kützing, Tab. Phycologicae, 2: 3, pl. 10, fig. 3, 1850; Bornet and Flahault, Revision des Nostocacées hétérocystées, 195, 1888; Forti in De Toni, Sylloge Algarum, 5: 395, 1907; Frémy, Myxo. d'Afr. équat. franc., 336, 1929; Geitler, Kryptogamenflora, 840, 1932.

= *Nostoc saxatile* Zeller, Algae collected from Arracam etc., J. Asiatic Soc. Bengal, 42: 179, 1873a; Hedwigia, 12: 171, 1873b.

Thallus at first globose, size variable, up to 2–3 mm diam., later bullose-tuberculate, hollow irregularly torn and perforate, lobed, fragile, young ones light pale green, older ones yellowish or variously coloured, filaments loosely entangled, flexuous; sheath distinct at the periphery of the thallus, yellowish at the surface, inside hyaline and diffluent; trichome 4–4.2 µ broad; cells spherical to oblong, longer than broad; heterocysts oblong, 5–6 µ broad; spores oblong or barrel-shaped, 6–8 µ broad, 7–10 µ long, contiguous when mature, epispore smooth hyaline or brownish.

On moist rocks in Kon-Choung and Kayeng, Mathay-Choung, Pegu, Burma (Zeller, 1873a, 171; 1873b, 179/180; Theobald, 1883, 23).

Elenkin (1938, p. 594) includes this under *Stratonostoc linckia* (Roth) Elenkin mut. ( = *Nostoc linckia* Roth).

### 8. **Nostoc spongiaeforme** Agardh ex Born. et Flah.

C. Ag., Syst. Alg. 22, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 197, 1888; Forti in De Toni, Sylloge Algarum, 5: 397, 1907; Frémy, Myxo. d'Afr. équat. franc., 337, fig. 279, 1929; Geitler, Kryptogamenflora, 839, fig. 531, 1932 (*non* Tilden).

Thallus at first globose, gelatinous, later expanding, verrucose, bullose, light blue-green, violet or brownish, filaments flexuous, loosely entangled; sheath diffluent in the inside, more or less distinct along the periphery, yellowish brown; trichome about 4 μ broad, blue-green to violet; cells partly cylindrical and up to 7 μ long, partly short barrel-shaped; heterocysts subspherical or oblong, 7–8 μ broad, somewhat longer than broad; spores oblong, 6–7 μ broad, and 10–12 μ long, epispore smooth, at first colourless, later yellowish.

In soils, Lahore (Singh, H. D., 1933, 106); on moist rocks in the river Gandack, Muzaffarpur in Bihar (Rao, G. S., 1939, 147), Shembaganur in Madras State (Frémy, 1942, 22); free floating in a tank, Rangoon, Burma (Skuja, 1949, 43).

Rao and Skuja give an idea of the variation in the species. Rao's specimens are narrower (cells 3.5–4 μ broad; heterocysts 4–6 μ broad and 6–10 μ long; spores 6–8 μ broad and 8–10 μ long). Skuja's Rangoon alga differs from the type in the somewhat thinner trichomes and in the colourless spore membrane (trichome 2.7–3.5 μ broad; heterocysts 4–5 μ broad and 7–8 μ long; spores round or oval, up to 7 μ broad and 8–10 μ long).

Elenkin (1938, 595) includes this species as a form, f. *spongiaeforme* (Ag.) Elenkin, under *Nostoc linckia* ( = *Stratonostoc linckia* (Roth) Elenkin).

Rao, C. B., (1936, 170; 1937b, 359) described two varieties, var. *tenue* (Pl. 68, Fig. 2) (*tenuis* of Rao), and var. *varians* both from Benaras (Pl. 75, Fig. 3). Var. *tenue* resembles the Rangoon alga in many characteristics. The two varieties are scarcely distinguishable from each other.

#### Var. **tenue** Rao, C. B.

The Myxophyceae of the United Provinces-II, Proc. Indian Acad. Sci., 3: 170, fig. 2F, 1936.

Pl. 68, Fig. 2

Plant mass small, gelatinous, thin, expanded, brownish black to brown; sheath hyaline or pale yellow, usually more or less diffluent, occasionally firm; trichomes densely entangled, 3–3.8 μ broad; cells spherical, subspherical, ellipsoidal or barrel-shaped, rarely cylindrical, those adjoining the heterocysts slightly drawn out, 2.8–6 μ long, end cells usually with a pointed apex; heterocysts spherical, subspherical, ellipsoidal or barrel-shaped, rarely cylindrical with flat or rounded ends, 4–6 μ broad and 5.5–9 μ long; spores in chains of 3–15, spherical, subspherical or ellipsoidal, 4.8–7.5 μ broad and 4.5–9 μ long, outer membrane smooth and hyaline.

On moist walls, Benaras (Rao, C. B., *loc. cit.*) and on moist soils, Ellore in Andhra (Rao, C. B., 1938a, 88).

J. De Toni (Diag. Alg. nov. I, Cent. 8: 753, 1939–46) writes it as var. *tenue* Rao, C. B.

### Var. **varians** Rao, C. B.

Myxophyceae of the United Provinces-III, Proc. Indian Acad. Sci., B, 6: 359, fig. 4B, 1937b.

Pl. 67, Fig. 3

Plant mass thin, spreading blue-green; trichomes loosely entangled, sometime individually enveloped by yellowish brown mucilage, 3–3.5 μ broad; cells barrel-shaped, 2–3.5 μ long, end-cell conical with a rounded apex; heterocysts barrel-shaped or cylindrical with rounded or flat ends, broader than the trichomes, 4.8–6.4 μ broad and 5.6–8 μ long; spores in long chains, cylindrical with rounded ends, sometimes ellipsoidal, rarely spherical, 4–4.8 μ broad and 4.8–10 μ long, with a smooth hyaline outer wall.

On moist soil at the end of the rainwater pool, Benaras (Rao, C. B., *loc. cit.*); Madras ( ! ).

The Madras alga agrees with Rao's except in that the apical cell is not conical.

### 9. **Nostoc carneum** Ag. ex Born. et Flah.

Agardh, Syst. Alg., 22, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 196, 1888; Forti in De Toni, Sylloge Algarum, 5: 395, 1907; Frémy, Myxo. d'Afr. équat. franc., 335, fig. 278, 1929; Geitler, Kryptogamenflora, 839, fig. 530, 1932.

= *Nostoc purpurascens* Kütz., Phyc. gene., 208, 1843.

Pl. 69, Fig. 6

Thallus at first globose, later bullose-tuberculate, leathery and irregularly expanded, gelatinous, flesh-coloured, reddish brown, violet, rose, or blue to olive green; filaments loosely contorted, flexuous; sheath indistinct, colourless; trichome (3–) 3.5–4 μ broad; cells oblongo-cylindrical, up to twice as long as broad; heterocysts oblong, 6 μ broad; spore oval to ellipsoidal, 6 μ broad, 5–10 μ long, epispore smooth and hyaline.

Floating in Kadeng-Choung near Natmadhi (Zeller, 1873b, 179).

Elenkin (1938, p. 595) included this under *N. linckia* (= *Stratonostoc linckia* (Roth) Elenkin).

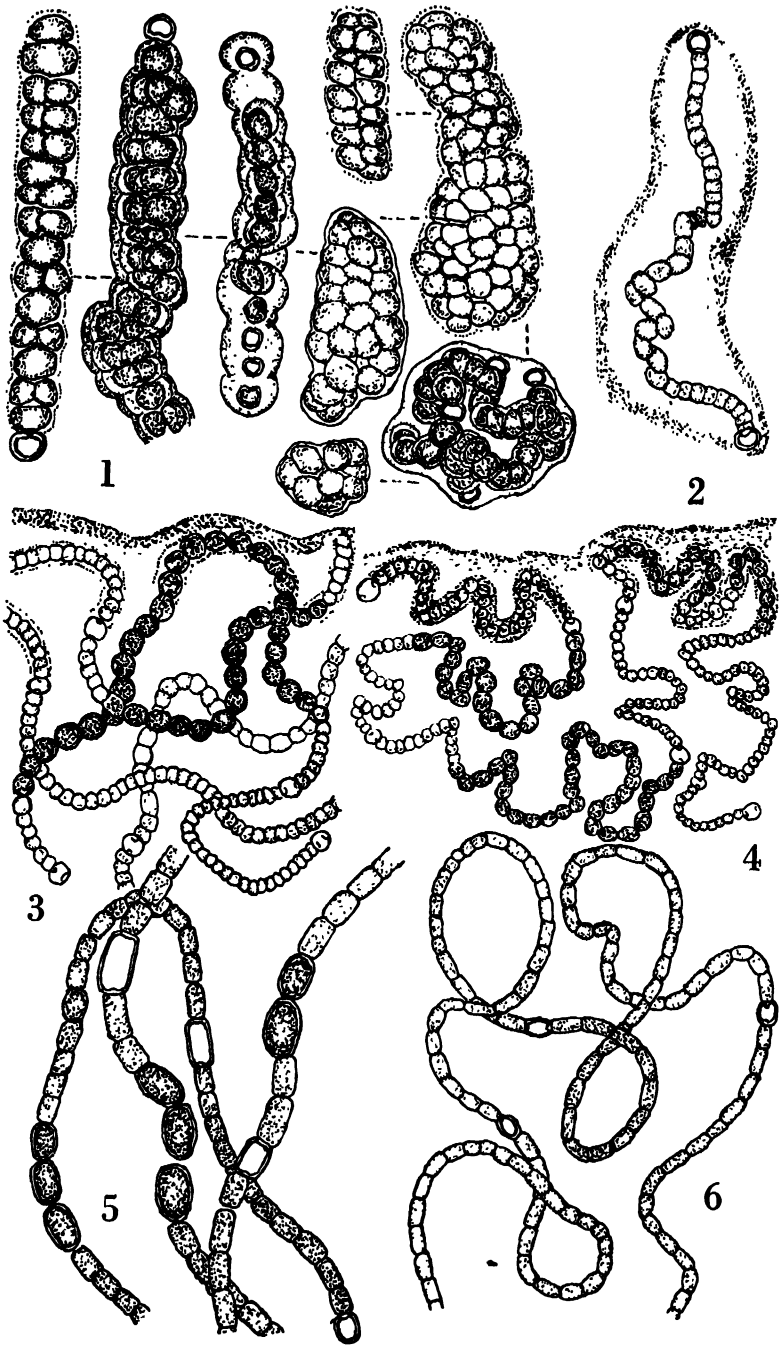

PLATE 69, Figs. 1–6.

1. *Nostoc punctiforme* v. *populorum* (after Geitler); 2. *N. paludosum* Kütz. (after Janczewski); 3. *N. piscinale* Kütz. (after Frémy); 4. *N. linckia* (Roth) Born. et Flah. (after Frémy); 5. *N. ellipsosporum* Rabenh. (after Frémy); 6. *N. carneum* Ag. (after Frémy).

f. **minor** Bharadwaja

The Myxophyceae of the United Provinces-I, Proc. Indian Acad. Sci., B, 2(1): 102, 1935.

Trichomes 3.1–4.2 μ broad, cells 3.2–6.4 μ long, heterocysts 4.2–5.7 μ broad and 4.2–6.3 μ long, spore 4.2–6.3 μ broad and 6.3–10.5 μ long.

In a stagnant pond, Benaras (Bharadwaja, *loc. cit.*), and in soils from Benaras, Gorakhpur, Mirzapur and Basti (Singh, R. N., 1939a, 59); on moist soil near water course amidst crop field, Bhimavaram in Andhra (Rao, C. B., 1938a, 88).

10. **Nostoc ellipsosporum** (Desm.) Rabenh. ex Born. et Flah.

Rabenhorst, Fl. Eur. Alg., 2: 169, 1865; Bornet and Thuret, Notes algologique, 2: 94, pl. 27, figs. 7–11, 1880; Bornet and Flahault, Revision des Nostocacées hétérocystées, 198, 1888; Forti in De Toni, Sylloge Algarum, 5: 398, 1907; Frémy, Myxo. d'Afr. équat. franc., 339, fig. 280, 1929; Geitler, Kryptogamenflora, 841, fig. 533, 1932; Frémy, Cyano. cotes d'Eur., 176, pl. 58, fig. 2, 1933.

(incl. var. *vaginis achromatices*)

Pl. 69, Fig. 5

Thallus gelatinous, irregularly expanded, attached by the lower surface, reddish brown; filaments flexuous, loosely entangled; trichome about 4 μ broad, light blue-green or olivaceous; cells cylindrical, 6–14 μ long; heterocysts subspherical, or oblong, 6–7 μ broad, 6–14 μ long; spores ellipsoidal to oblong cylindrical, 6–8μ broad, 14–19μ long, epispore smooth, hyaline or brownish.

In a stream, Whay-do-Choung, Burma (Zeller, 1873b, 179; Theobald, 1883, 23); in soils, Lahore, Pakistan (Singh, H. D., 1933, 106); in salt-water puddles, Mogalthur, Andhra (Rao, C. B., 1938a, 88); in soils of Benaras, Gorakhpur, Mirzapur and Basti (Singh, R. N., 1939a, 59).

Heterocysts and spores in the Mogalthur alga are smaller (heterocysts 4–6.4 μ broad and 6.4–9.6 μ long; spores 6.4–8 μ broad and 8–12 μ long).

Elenkin (1938, p. 595) includes this as a form under *N. linckia* ( = *Stratonostoc linckia* (Roth) Elenkin).

Var. **violacea** Rao, C. B.

The Myxophyceae of the United Provinces-III, Proc. Indian Acad. Sci., B, 6: 359, fig. 4C, 1937b.

Pl. 68, Fig. 4

Plant mass gelatinous, irregularly expanded, dark violet; filaments flexuous, loosely entangled, light-violet; trichome 3.2–3.5 μ broad, constricted at the cross-walls; cells almost quadrate or cylindrical, 2.4–8 μ long; heterocysts almost spherical or cylindrical with rounded or flat ends, 4–6.4 μ broad and 4.8–8 μ long; spores ellipsoidal, almost spherical or cylindrical, 4.8–6.4 μ broad, and 5.6–15 μ long with a hyaline smooth outer wall.

On the sides of a tank, above the water level, Benaras (Rao, *loc. cit.*).

### 11. **Nostoc humifusum** Carmichael ex Born. et Flah.

Carm., ex Harvey, Hooker's British Flora, 2: 399, 1833; Born. et Flah. Revision des Nostocacées hétérocystées, 201, 1888; Forti in De Toni, Sylloge Algarum, 5: 402, 1907; Frémy, Myxo. d'Afr. équat. franc., 341, fig. 282, 1929; Geitler, Kryptogamenflora, 842, 1932.

= *Nostoc granulare* Rabenhorst, Fl. Eur. Alg., 2: 163, 1865.

Thallus gelatinous or mucilaginous, irregular with variable size, sometimes punctiform, sometimes many smaller ones uniting and expanding, tuberculate; olivaceous or brownish in colour, attached by the under surface; filaments twisted and flexuous, densely entangled; sheath mostly indistinct, rarely distinct and yellowish brown; trichomes 2.2–3 μ broad, more or less blue-green; cells subspherical or nearly twice as long as broad; heterocysts 3 μ broad, subspherical; spores subspherical or oval, 4 μ broad, 6 μ long, epispore smooth and yellowish.

In stagnant freshwater, Elephant point, Pegu, Burma (Zeller, 1873b, 179; Theobald, 1883, 23); in paddyfield soils from Khandala and Lonavla near Bombay (Gonzalves and Gangla, 1949, 54).

Elenkin (1938, p. 595) includes this as a form under *Nostoc linckia* (= *stratonostoc linckia* (Roth) Elenkin).

#### Var. **fluitans** West et West

Freshwater Algae from Burma, Ann. roy. bot. Gdn., 6: 240, 1907.

Thallus gelatinous, free-floating among other algae, subglobose, or irregularly subelliptic, compressed, 1.5–5 mm diam.; cells 2.5–2.8 μ diam.; heterocysts 3.8 μ diam.

Free-floating in a marsh in an open space in forest near Mansang, Hsipaw, Burma (West et West, 1907, 240).

### 12. **Nostoc calcicola** Brébisson ex Born. et Flah.

Brébisson in Meneghini, Monographia Nostochinearum italicarum, 121, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 202, 1888; Forti in De Toni, Sylloge Algarum, 5: 402, 1907; Geitler, Kryptogamenflora, 842, fig. 534, 1932 (*non* Agardh).

Pl. 68, Fig. 1

Thallus mucilaginous, slightly diffluent, expanded, olive, grey or blue green, often up to 5 cm in diam., filamently loosely entangled; sheath mostly indistinct, or distinct only at the periphery of the thallus, colourless or yellowish brown; trichome 2.5 μ broad, pale blue-green; cells barrel-shaped, subspherical, rarely longer than broad; heterocysts subspherical, 4 (–5) μ broad; spores subspherical, 4–5 μ broad, with smooth yellowish membrane.

In cultures of paddyfield soil, Thana near Bombay (Gonzalves and Gangla, 1949, 53).

Elenkin (1938, p. 595) includes it under *Stratonostoc linckia* (Roth) Elenkin.

### 13. **Nostoc passerinianum** (De Not.) Bornet ex Born. et Flah.

Bornet in Bornet and Thuret, Notes algologiques, 2: 99, 1880; Bornet and Flahault, Revision des Nostocacées hétérocystées, 199, 1888: Forti in De Toni, Sylloge Algarum, 5: 399, 1907; Geitler, Kryptogamenflora, 843, 1932.

Thallus crustaceous, expanded, orbicular, gelatinous, membranous, attached by the lower surface, olive-green, olive yellow or brown, 1–2 cm diam.; filaments densely entangled, flexuous, mostly parallel; trichome 5 μ broad, torulose; cells short barrel-shaped, or ellipsoidal, 5–7 μ long; heterocysts 5 μ broad, subspherical or oblong; spores oval, 6 μ broad, 8 μ long, epispore smooth, yellowish.

Kyauktan and near it, Burma (Skuja, 1949, 43).

Elenkin (1938, p. 595) includes this as a form under *Stratonostoc linckia* ( = *Nostoc linckia*).

### 14. **Nostoc muscorum** Ag. ex Born. et Flah.

Agardh, Dispositio Algar. Sueciae, 44, 1812; Bornet et Flahault, Revision des Nostocacées hétérocystées, 200, 1888; Forti in De Toni, Sylloge Algarum, 5: 400, 1907; Frémy, Myxo. d'Afr. équat. franc., 340, fig. 281, 1929; Geitler, Kryptogamenflora, 844, fig. 535, 1932.

Pl. 70, Fig. 2

Thallus gelatinous-membranous, irregularly expanded, attached by the lower surface, tuberculate, dull olive or brown, 2–5 cm diam.; filaments densely entangled; sheath distinct only at the periphery of the thallus, yellowish brown; trichome 3–4 (–5) μ broad; cells short barrel-shaped to cylindrical, up to twice as long as broad; heterocysts nearly spherical, 6–7 μ broad; spores oblong, many in series, 4–8 μ broad, (7–) 8–12 μ long, epispore smooth and yellowish.

On moist soil, Panchgani (Schmidle, 1900b, ) and paddy-field soils from Thana, Dahisar and Goregaon in Bombay State (Gonzalves and Gangla, 1949, 50); Lahore in Pakistan (Ghose, 1924, 340); Rangoon in Burma (Ghose, 1927a, 223*; 1927, 81; Skuja, 1949, 43).

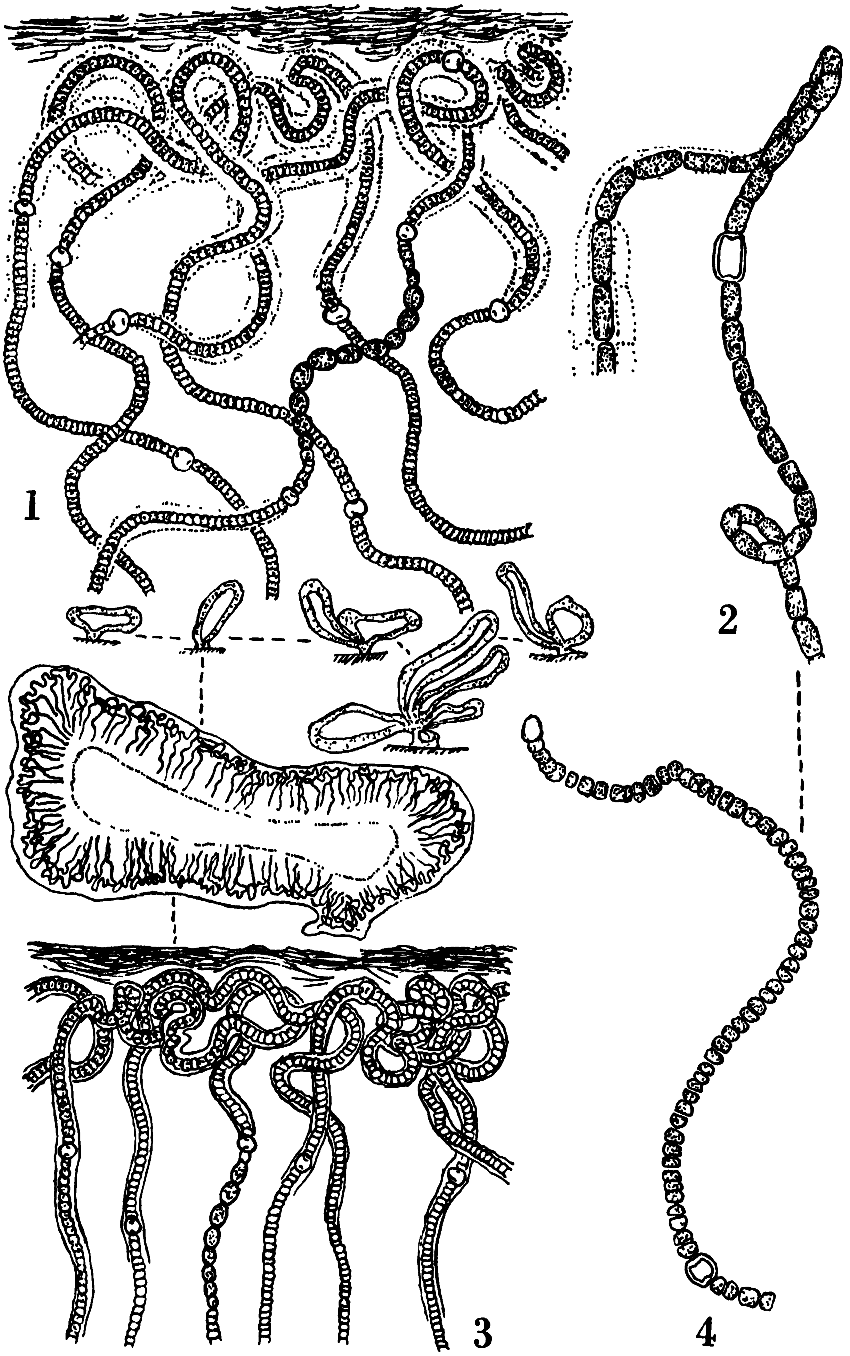

PLATE 70, Figs. 1–4.

1. *Nostoc verrucosum* Vaucher (after Frémy); 2, 4. *N. muscorum* (after Bornet and Thuret); 3. *N. parmelioides* Kütz. (after Frémy).

Spores have not been observed for a long time. Bristol's was the first report but the material has since been identified as another species. Geitler (1932, p. 847) states that the spores have been observed only once. It is interesting to note here that Banerji (1938, 98) reported the occurrence of spores in his Bengal material (6–8 μ broad and 8–12 μ long).

Elenkin (1938, p. 595) includes this as a form of *Stratonostoc linckia* (Roth) Elenkin (= *Nostoc linckia* Roth).

* Ghose writes it as *N. muscorum* Kütz.

### 15. **Nostoc commune** Vaucher ex Born. et Flah.

Vaucher, Histoire des Conferves d'eau douce, 222, pl. 16, fig. 1 (mala), 1803; Bornet et Flahault, Revision des Nostocacées hétérocystées, 203, 1888: Forti in De Toni, Sylloge Algarum, 5: 404, 1907; Frémy, Myxo. d'Afr. équat. franc., 342, fig. 283, 1929; Geitler, Kryptogamenflora, 845, fig. 536, 537, 1932; Frémy, Cyano. cotes d'Eur., 177, pl. 58, fig. 3, 1933.

= *N. kurzianum* Zeller, Algae collected in Arracan etc., J. Asiatic Soc., Bengal, 42: 179, 1873a; Hedwigia, 12: 171, 1873b.

Pl. 68, Fig. 3

Thallus firm, gelatinous, at first globose, later flattened, expanding, undulated, membranous or leathery, sometimes irregularly torn, often perforated, many centimeters diam., blue-green, olivaceous or brown; filaments flexuous, entangled; sheath mostly distinct only at the periphery, thick, yellowish brown, often lamellated, inside the thallus more or less distinct, but hyaline; trichome 4.5–6 μ broad, cells short barrel-shaped or nearly spherical, mostly shorter or a little longer than broad, 5 μ long; heterocysts nearly spherical, about 7 μ broad; spore only once observed, as big as the vegetative cells epispore smooth colourless.

On moist soils, rocks and in stagnant waters — wet slopes of Wa-tha-Choung, Pegu, Burma (Zeller, 1873a, 179; 1873b, 171; Theobald, 1883, 23); Neral near Bombay (Schmidle, 1900b, 161), road slimes, Calcutta (Biswas, 1925, 6), Rice fields, Faridpur and Calcutta (Banerji, 1935, 298; 1938, 98); River Moosi and ponds, Hyderabad (Ghousuddin, 1936, 150), Shembaganur in Madras State (Frémy, 1942, 22); on moist logs wood in the littoral portion of a lake, Chingleput ( ! ); Lahore in Pakistan (Ghose, 1919, 11).

Elenkin (1938, p. 613) includes this in *Stratonostoc*, *S. commune* (Vaucher) Elenkin.

### 16. **Nostoc microscopicum** Carm. ex Born. et Flah.

Carmichael in Harvey, Hooker's British Flora, 5: 399, 1833; Bornet and Flahault, Revision des Nostocacées hétérocystées, 210, 1888; Forti in De Toni, Sylloge Algarum, 5: 413, 1907; Frémy, Myxo. d'Afr. équat. franc., 348, fig. 287, 1929; Geitler, Kryptogamenflora, 849, 1932.

Thallus spherical or ellipsoidal, about 1 cm diam., or only very seldom larger, soft, but with a firm outer surface, first glistening later olivaceous or brown; filaments loosely entangled; sheath more or less distinct, yellowish; trichome 5–8 μ broad, blue-green, or olive-green; cells subspherical or barrel-shaped; heterocysts nearly spherical, 7 μ broad; spores oval, 6–7 μ broad, 9–15 μ long, olivaceous, epispore smooth.

Epiphytic and on moist surfaces — Matheran near Bombay (Schmidle, 1900b, 161), Shembaganur in Madras State (Frémy, 1942, 43); on wet rocks, Yadaganurva in Ceylon (West and West, 1902, 202); barks of various trees, Rangoon, Mergui and Maymyo islands in Burma (Ghose, 1927a, 224; 1927c, 248; 1927d, 255; Skuja, 1949, 43).

### 17. **Nostoc verrucosum** Vaucher ex Born. et Flah.

Vaucher, Histoire des Conferves d'eau douce, 225, pl. 16, fig. 3, 1803; Bornet and Flahault, Revision des Nostocacées hétérocystées, 216, 1888; Forti in De Toni, Sylloge Algarum, 5: 419, 1907; Frémy, Myxo. d'Afr. équat. franc., 350, fig. 290, 1929; Geitler, Kryptogamenflora, 854, fig. 43, 542 and 543, 1932.

Pl. 70, Fig. 1

Thallus often gregarious, up to 10 cm in diam., at first spherical or subspherical, solid, gelatinous and firm, surface undulate or verrucose, later hollow, vesicular, soft and torn, blackish green or olive green, or brownish green; filaments flexuous and densely entangled at the periphery; sheath thick, yellowish brown in the peripheral layers, inner ones hyaline, and diffluent; trichome 3–3.5 μ broad, cells short barrel-shaped, shorter than broad; heterocysts 6 μ broad, subspherical; spores oval, 5 μ broad, 7 μ long, epispore smooth yellowish.

On moist soil and rocks — Lahore (Singh, H. D., 1933, 106); Chamba in Punjab (Singh, V. P., 1941, 252); on the bed of a stream, Kodaikanal ( ! )

The Chamba form varies from the type (cells 3–3.2 μ broad; heterocysts up to 3.8 μ broad, spores 3.8–5 μ broad and 5.3–7.7 μ long). The cells are broader in the Kodaikanal algae (3.9–5.2 μ).

Elenkin includes this in *Stratonostoc* (= *S. verrucosum* (Vauch.) Elenk.).

### 18. **Nostoc coeruleum** Lyngbye ex Born. et Flah.

Lyngbye, Hydrophytologia danica, 201, pl. 68, fig. B, 1819; Bornet and Flahault, Revision des Nostocacées hétérocystées, 213, 1888; Forti in De Toni, Sylloge Algarum, 5: 416, 1907; Geitler, Kryptogamenflora, 1932; Frémy, Cyano. cotes d'Eur., 178, pl. 59, fig. 3, 1933.

= *Nostoc gregarium* Thuret in Kützing, Species Algarum, 296, 1849.

Thallus small, up to 1 cm diam., globose, solid, pale blue-green, seldom brownish, solitary or aggregated, not infrequently proliferated, with a firm outer layer; filaments densely entangled, flexuous; sheath mostly indistinct; trichome 5–7 μ broad, torulose; cells short, barrel-shaped or subspherical; heterocysts subspherical up to 10 μ broad; spores not known.

On submerged plants, Calcutta (Martens, 1871a, 170; Prain, 1905, 334).

Elenkin (1938, p. 572) places this species in *Sphaeronostoc* (*S. coeruleum* (Lyngb.) Elenk.).

### 19. **Nostoc hatei** Dixit

The Myxophyceae of the Bombay Presidency-I, Proc. Indian Acad. Sci., B, 3: 101, fig. 30, 1936.

Pl. 67, Fig. 2

Thallus almost spherical, at first attached, later free-floating, up to 2 cm diam., trichomes 3.7–6 μ broad, irregularly curved and densely entangled; cells spherical or ellipsoidal; heterocysts single, or in short chains of 2–5, almost spherical rarely slightly barrel-shaped, sometimes flattened, 3.6–5 μ broad, and 5 μ long; spores not observed.

On aquatic plants in a stagnant pond, Santa Cruz, Bombay (Dixit, *loc. cit.*).

### 20. **Nostoc parmelioides** Kütz. ex Born. et Flah.

Kützing Phyc. gene., 206, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 219, 1888; Forti in De Toni, Sylloge Algarum, 5: 422, 1907; Frémy, Myxo. d'Afr. équat. franc., 352, fig. 291, 1929; Geitler, Kryptogamenflora, 857, fig. 546, 1932.

Pl. 70, Fig. 3

Thallus discoid, or ligulate, hard, attached at one stage, sometimes subspherical with a firm outer layer, up to 3 cm diam.; filaments radiating from a centre, nearly parallel in the middle, densely entangled at the periphery; sheath distinct, mostly at the periphery, yellow, inside hyaline and diffluent; trichome 4–4.5 μ broad; cells short barrel-shaped, subspherical; heterocysts spherical, 6 μ broad; spores oval 4–5 μ broad, 7–8 μ long, epispore smooth and yellowish.

In the environs of Shembaganur in Madras State (Frémy, 1942, 22).

Elenkin (1938, p. 626) includes this species under *Stratonostoc verrucosum* (Vaucher) Elenk.

### 21. **Nostoc pruniforme** Ag. ex Born. et Flah.

Agardh, Disposito Alg. Sueciae, 45, 1812; Bornet and Flahault, Revision des Nostocacées hétérocystées, 215, 1888; Forti in De Toni, Sylloge Algarum, 5; 418, 1907; Frémy, Myxo. d'Afr. équat. franc., 350, fig. 288, 1929; Geitler, Kryptogamenflora, 860, fig. 548, 1932.

Thallus globose or ellipsoidal, up to the size of a hen's egg, olivaceous or blue-green later blackish brown, soft and hollow inside, outer surface leathery; filaments loosely entangled, radiating from a centre; sheath mostly distinct, hyaline or seldom yellow; trichome 4–6 μ broad, cells short barrel-shaped or sometimes longer than broad; heterocysts 6–7 μ broad, subspherical; spores spherical up to 10 μ broad.

In cultures of soil, Lahore (Singh, H. D., 1933, 106).

Descriptions of spores are based on Naumann's observation. Geitler (1932) doubts whether these may not be only enlarged vegetative cells instead of spores.

### 22. **Nostoc sphaericum** Vaucher ex Born. et Flah.

Vaucher, Histoire des Conferves d'eau douce, 223, pl. 16, fig. 2, 1803; Bornet and Flahault, Revision des Nostocacées, hétérocystées, 208, 1888; Forti in De Toni, Sylloge Algarum, 5: 409, 1907; Frémy, Myxo. d'Afr. équat. franc., 345, fig. 284, 1929; Geitler, Kryptogamenflora, 850, fig. 539b, 1932; Frémy, Cyano. cotes d'Eur., 177, pl. 59, fig. 1, 1933. *non* Menegh.

Thallus free, globose, 1–15 mm diam., later irregularly plicate-tuberculate, thick, sometimes 6–7 cms in diam., olive-green, yellow or violet brown, with firm outer layer; filaments flexuous, densely entangled; trichome 4 rarely 5 μ broad; cells compressed spherical or barrel-shaped; heterocysts (4–) 6 μ broad, sub-spherical; spores oval 5 (4–6) μ broad, 7 (6–8) μ long, epispore thick and brownish.

On moist soil, in cultures of Usar soil, uncultivated and cultivated rice and wheat fields and in stagnant pieces of water — Neral near Bombay (Schmidle, 1900b, 161), Calcutta (Biswas, 1925, 7; Banerji, 1938, 98), Shembaganur (Frémy, 1942, 22), and Allahabad (Mitra, 1951, 359/362) and on moist rocks near water falls, Courtallum ( ! ).

The Courtallum alga shows a greater range of dimensions (cells 3.9–5.2 (–6) μ broad, up to 10.5 μ long; heterocysts 5.2-6.6 μ broad; spores 5.2–7.9 (–9.2) μ broad and 11.8–19.7 μ long.

Elenkin includes this in *Stratonostoc* (*S. commune* (Vaucher) Elenk.).

### 23. **Nostoc amplissimum** Setchell

Notes on Cyanophyceae III, Erythea, 7: 50, pls. 2, 3, figs. 1, 2, 1899; Forti in De Toni, Sylloge Algarum, 5: 421, 1907.

Colonies at first spherical later becoming hollow and lobulated, expanding and becoming irregular verrucose, brownish yellow sacs, up to 60 × 30 cms. 2–10 mm thick; filaments numerous variously arranged, near upper and lower surfaces contorted, in the middle nearly horizontal and parallel; sheath of the peripheral filaments distinct, and colourless, lacking in the central ones; trichomes 2–3 μ broad, more or less torulose; cells (2–) 3.5–5 μ in length, subspherical, or short cylindrical; heterocysts about (3–) 4 μ diam.; spores ellipsoidal, 3–4 μ broad, 5–6 μ long, epispore smooth and brown.

In a small stream by the hill side near Bishanpur, Assam (Biswas, 1930, 189).

## SPECIES INQUIRENDAE

### **Nostoc limosum** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42: 179–180, 1873b; Hedwigia, 12: 171, 1873b. — River flats on the Irrawady and Hleing, Burma.

### **N. heterothrix Zeller**

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42: 179, 1873; Hedwigia, 12: 171, 1873.— On the sides of Bala-choung, and on the Irrawady at Khyoung-gyee, Burma.

## ANABAENA Bory

Dict. class. d'hist. nat., 1: 307, 1822; Bornet and Flahault, Revision des Nostocacées hétérocystées, 224, 1888.

Trichomes uniformly broad throughout or apices alone somewhat attenuated, sheath absent or more or less diffluent, forming a free, torn or floccose or soft mucilaginous thallus; heterocysts generally intercalary; spores single or in long series, formed from near the heterocysts or in between the heterocysts.

Type species: *A. oscillarioides* Bory.

Bory described the genus 'Anabaina' with five species, of which *A. oscillarioides* is the type.

### KEY TO THE SPECIES

1. Akinetes spherical or subspherical .................................... 2
1. Akinetes otherwise .................................... 7
    2. Akinetes usually contiguous to the heterocysts sometimes shortly ellipsoidal .................................... 3
    2. Akinetes not contiguous .................................... 4

3. Trichomes straight, cells without pseudovacuoles, akinetes 8–12 μ broad 1. *A. sphaerica* (p. 393)

3. Trichomes spirally coiled, with pseudovacuoles, akinetes broader 2. *A. spiroides* (p. 395)

4. Akinetes not contiguous with the intercalary heterocyst, but occasionally next to the terminal heterocyst, sometimes short ellipsoid 3. *A. oryzae* (p. 396)

4. Akinetes remote from the heterocysts, usually spherical ............... 5

5. Trichomes 5–7.5 μ wide, heterocyst broader than the trichome ............... 6

5. Trichomes 2.5–4 μ broad, one or more in a special sheath, akinetes 6.5–10 μ broad 4. *A. khannae* (p. 396)

5. Trichomes 2–3.5 μ broad not in a special sheath, heterocysts narrower, akinetes 3.5–5.5 μ broad .................................... 5. *A. anomala* (p. 398)

6. Trichomes 5–5.6 μ broad, end-cell rounded, akinetes 4.8–8 μ broad 6. *A. fertilissima* (p. 398)

6. Trichomes 6–7.5 μ broad, end-cell pointed, akinetes 4 μ wide 7. *A. gelatinicola* (p. 398)

7. Akinetes ellipsoidal ............................................................ 8

7. Akinetes cylindrical ............................................................ 20

8. Akinetes usually contiguous to the heterocysts ...................... 9

8. Akinetes away from the heterocysts about twice as long as broad ....... 16

9. Several trichomes commonly with a well-defined mucilaginous sheath, akinetes shortly ellipsoidal ............................................... 10

9. Trichomes not so arranged ............................................... 11

10. Akinetes single on either side of the spherical heterocysts 8. *A. ambigua* (p. 400)

10. Akinetes in series of 4–5, heterocysts cylindrical or barrel-shaped 9. *A. vaginicola* (p. 401)

11. Akinetes on one side of the heterocyst only ................................ 12

11. Akinetes on both sides of the heterocysts ................................ 14

12. Akinetes with a fine spiny or papillate wall ....... 10. *A. füllebornii* (p. 401)

12. Akinetes with a smooth epispore ................................ 13

13. Akinetes 15–21 μ broad, gas-vacuoles absent ................ 11. *A. volzii* (p. 403)

13. Akinetes 7–18 μ broad, gas-vacuoles present ....... 12. *A. aphanizomenoides* (p. 405)

14. Akinetes 12.3–13.5 μ broad up to 17 μ long ......... 13. *A. beckii* (p. 405)

14. Akinetes 8–10.5 μ broad, up to twice as long as broad ............... 15

15. Trichomes 2.5–4 μ broad, about twice as long as broad .. 14. *A. orientalis* (p. 405)

15. Trichomes 5.2–6.3 μ broad, about as long as broad, akinetes in chains 15. *A. iyengarii* (p. 406)

16. Cells about as long as broad, trichome markedly constricted at the cross-walls ............................................... 17

16. Cells usually longer than broad, trichome not markedly constricted at the cross-walls ............................................... 19

17. Trichomes regularly circinate....................... 16. *A. ballyganglii* (p. 409)

17. Trichomes not so coiled............................................... 18

18. Akinetes with pointed and commonly protruded ends surrounded by a special mucilaginous sheath, heterocysts rare ... 17. *A. naviculoides* (p. 410)

18. Akinetes with rounded ends, devoid of such a sheath, heterocysts normally developed ....................... 18. *A. doliolum* (p. 410)

19. Akinetes barrel-shaped with flattened ends ........... 19. *A. variabilis* (p. 410)
19. Akinetes barrel-shaped with flattened ends, heterocysts cylindrical, end-cells pointed .... 19. *A. variabilis var. kashiensis* (p. 413)
19. Akinetes ellipsoidal with rounded ends .. 19. *A. variabilis var. ellipsospora* (p. 411)
    20. Akinetes usually contiguous to the heterocysts ........................ 22
    20. Akinetes mostly remote from the heterocyst ......................... 21
21. Trichomes often nearly straight and parallel, 3-6 μ broad, akinetes 6–10 μ broad 20. *A. laxa* (p. 413)
21. Trichomes spirally coiled, 8–10 μ broad, with gas-vacuoles, akinetes 16–18 μ broad, up to 34 μ long ............................ 21. *A. circinalis* (p. 414)
    22. Cells 4–6 μ broad, barrel-shaped as long as broad .................... 23
    22. Cells 4–8 μ broad, ellipsoidal, usually with pseudovacuoles, akinetes elongate with rounded ends................. 22. *A. flos-aquae* (p. 414)
23. Akinetes bent or curved, 2–3 (-4) times as long as broad.... 23. *A. utermöhli* (p. 415)
23. Akinetes not bent or curved ........................................... 24
    24. Akinetes about twice as long as broad with flattened ends, end cells conical .... 24. *A. torulosa* (p. 415)
    24. Akinetes up to 3–4 times as long as broad with round ends; end cells rounded .... 25. *A. oscillarioides* (p. 417)

### 1. **Anabaena sphaerica** Bornet et Flahault

Revision des Nostocacées hétérocystées, 228, 1888; Forti in De Toni, Sylloge Algarum, 5: 440, 1907; Frémy, Myxo. d'Afr. équat. franc., 361, fig. 295, 1929; Geitler, Kryptogamenflora, 878, 1932.

Thallus floccose, blue-green; trichomes moniliform, straight, arranged parallel, 5–6 μ broad, with an indistinct mucilaginous sheath; cells spherical to short barrel-shaped; end cells rounded; heterocysts subspherical, 6–7 μ broad; spores on one or both sides of the heterocysts, subspherical to oval, 8–12 μ broad, 12–18 μ long, one to few together, epispore smooth, yellowish brown.

In stagnant freshwater, and salt-water ponds and lakes, also in rivers.—Dadar, Bombay (Schmidle, 1900b, 161); Dhapa Salt lakes and River Hooghly, Calcutta (Banerji, 1938, 98; Biswas, 1942, 198); Madras (Ganapati, 1940a, 246).

The spores in the Bengal alga are 10–12 μ broad.

### Var. **tenuis** West, G. S.

J. Linn. Soc. Bot., 18: 171, 1907; Frémy, Myxo. d'Afr. équat. franc., 361, 1929; Geitler, Kryptogamenflora, 878, fig. 560b, 1932.

Pl. 71, Fig. 10

Cells 4–5 μ broad, heterocysts 5.5 μ broad, spores 10 × 11–14 μ.

In stagnant pond, Benaras (Bharadwaja, 1935, 103); in a tank, Delhi (R. Senior-White ex Fritsch, 1949, 153).

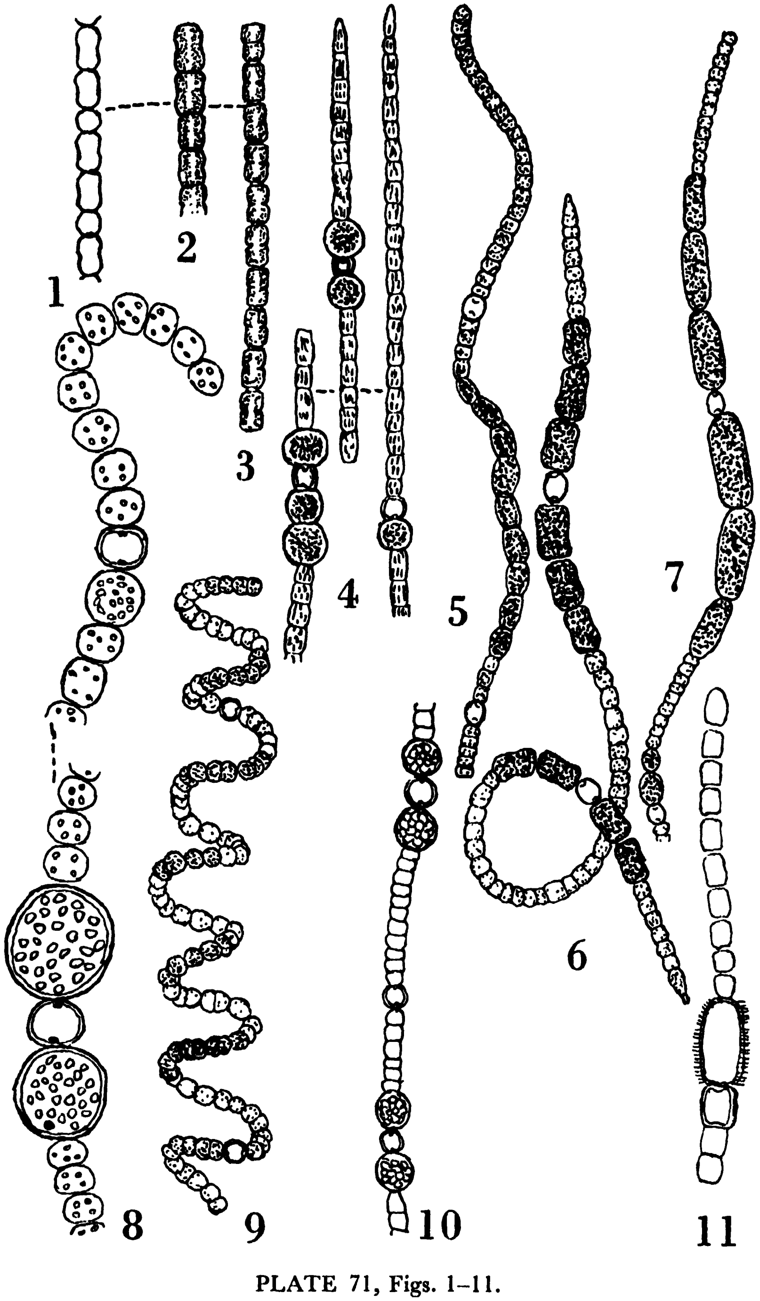

PLATE 71, Figs. 1–11.

1. *Anabaena constricta* (Szafer) Geitler (after Koppe); 2. *A. constricta* (after Lauterb.); 3. *A. constricta* (after Skuja); 4. *A. aphanizomenoides* Forti (after Forti); 5. *A. variabilis* Kütz. (after Frémy); 6. *A. torulosa* (Carm.) Lagerh. (after Frémy); 7. *A. oscillarioides* Bory (after Frémy); 8. *A. sphaerica* v. *attenuata* Bharadw. (after Bharadwaja); 9. *A. spiroides* v. *crassa* (after Smith, G. M.); 10. *A. sphaerica* v. *tenuis* West, G. S. (after Raciborski); 11. *A. fuellebornii* Schmidle (after Frémy).

Bharadwaja (1935) gives the dimensions of this variety as heterocysts 4.5–6.3 μ diam., spores 10–13 μ broad and 11–14 μ long.

### Var. **attenuata** Bharadwaja

The Myxophyceae of the United Provinces I — Proc. Indian Acad. Sci., B, 2: 103, fig. 5 G-H, 1935.

Pl. 71, Fig. 8

Thallus floccose, gelatinous, thin, free-floating, pale blue-green; trichomes blue-green, curved or straight, more or less entangled with each other, 3.2–5.2 μ broad, slightly attenuated at the ends, with rounded end-cells, without a mucilage sheath; cells spherical or slightly barrel-shaped, 3–6 μ long; heterocysts intercalary, or slightly pressed from both sides, (4–) 5.2–6.2 (–8) μ diam.; spores single (or two together) on one or both sides of the heterocyst, spherical or oval, 10.5–12.6 μ broad and 10.5–14.7 (–16.5) μ long, with smooth yellow outer wall.

In stagnant waters, rivers and on moist soils. — Benaras (Bharadwaja, *loc. cit.*) Rao, C. B., 1937b, 363), Muzaffarpur in Bihar (Rao, C. B., 1939, 147), paddy-fields, Nalbari, Kamrup in Assam (Parukutty, 1939, 233), New Delhi (Rao, C. S., 1940, 128), River Hooghly, Calcutta (Biswas, 1942, 198) and rain water pools, Chepauk, Madras ( ! ).

Fritsch (1949, p. 153) considers that var. *tenuis* and var. *attenuata* do not appreciably differ from the type of the species.

### 2. **Anabaena spiroides** Klebahn

Flora, 80:125, pl. 4, figs. 11–13, 1895; Forti in De Toni, Sylloge Algarum, 5: 445, 1907; Frémy, Myxo. d'Afr. équat. franc., 361, fig. 296, 1929; Geitler, Kryptogamenflora, 881, 1932.

Pl. 71, Fig. 9

Trichome single, free-floating, regularly spirally coiled, with thick and mucilaginous sheath, spirals 45–54 μ broad and 40–50 μ distant; cells spherical, 6.5–8 μ broad, mostly somewhat shorter than broad, with gas-vacuoles; heterocysts subspherical, 7 μ broad; spores at first spherical, later elongate, slightly bent, in optical longitudinal section hexagonal, next to the heterocyst or away from it, 14 μ broad.

Planktonic in tanks and rivers. — Tank Kalawewa, Balaluwewa and Neravieawewa near Dumbulla, Senadiniya-gewawewa near Haberane, Ceylon (Crow, 1923b, 143); Umdas Sagar, Hyderabad (Ghousuddin, 1936, 150); River Hooghly, Calcutta (Biswas, 1942, 198); Rangoon and Kyauktan in Burma (Skuja, 1949, 43).

Var. **contracta** Klebahn

*loc. cit.*, Geitler, Kryptogamenflora, 882, 1932.

Spirals 20–25 μ broad, 10–15 μ distant; cells 7–8 μ broad; immature spores spherical, away from the heterocysts, 14 μ broad.

Plankton. — lake at Colombo, Ceylon (Lemmermann, 1907, p. 267); Lahore (Ghose, 1924, 341); Rangoon (Ghose, 1926, 249; 1927b, 79).

### 3. **Anabaena oryzae** Fritsch

The genus *Anabaena*, J. Indian bot. Soc., 28: 135, figs. 1–16, 1949.

= *A. gelatinosa* Fritsch ex De 1939 (*nomen nudum*) *non* Reinsch *non* Wood.

Pl. 72, Fig. 3

Thallus soft, green, gelatinous, membranous, trichomes short, straight, densely aggregated, generally parallel cells 2.5–3 μ broad, more or less barrel-shaped, 1½–2 times as long as broad; heterocysts terminal and intercalary, broader than the vegetative cells, 3–3.5 μ broad, terminal ones conical and twice longer than broad, intercalary ones, single, or 2–3 in series, generally barrel-shaped, sometimes spherical, single; spores rarely single next to the terminal heterocyst, commonly away from the intercalary heterocysts, single or 2–7 in series, subspherical or short ellipsoidal, 5 × 5, 6.5 × 7, 5 × 5.5, 5 × 6.5, 5 × 6 μ, exospore yellowish brown.

In rice fields, Faridpur, Bengal (Fritsch, *loc. cit.*; De, 1939, 125).

### 4. **Anabaena khannae** Skuja

Zur Süsswasseralgenflora Burmas, 41, pl. 7, figs. 1–5, 1949.

Pl. 75, Fig. 2

Filaments creeping, attached, more or less parallel to the substratum, elongate straight or bent, solitary or rarely two in a common mucilaginous sheath, 15–20 μ broad, sheath up to 7 μ broad, colourless or yellowish ochraceous, generally diffluent; trichomes 2.5–4 μ broad, cells barrel shaped or cylindrical, apex rounded, or cylindrical-oval, as long as broad or up to 6 times as long; heterocysts terminal or intercalary, barrel-shaped or cylindrical; apex rounded, 3–3.5 μ broad, 3.5–6 μ long; spores formed in series, globose ellipsoidal, 6.5–10 μ or 8–9.5 × 7 μ, epispore brownish, granular punctate, mesospore hyaline, moderately thick, endospore thin, colourless, formed generally away from the heterocyst.

On the leaves of *Carex* near the 10th Prome Road, and on *Nitella* in a running soiled trench water, Rangoon, Burma (Skuja, *loc. cit.*).

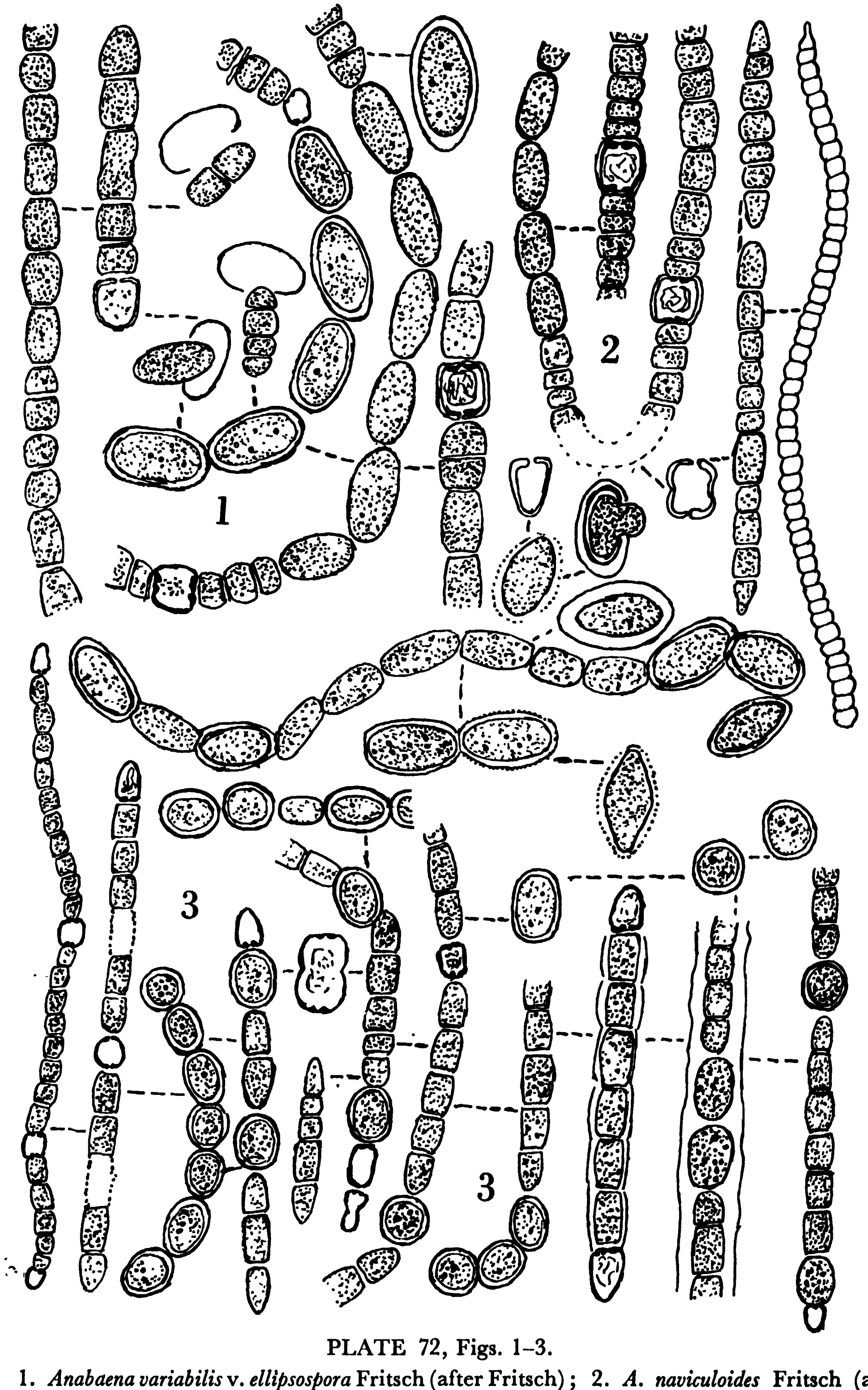

PLATE 72, Figs. 1–3.

1. *Anabaena variabilis* v. *ellipsospora* Fritsch (after Fritsch); 2. *A. naviculoides* Fritsch (after Fritsch); 3. *A. oryzae* Fritsch (after Fritsch).

### 5. **Anabaena anomala** Fritsch

The genus *Anabaena* etc., J. Indian bot. Soc., 28: 146, figs. 60–73, 1949.

= *A. thermalis* Vouk var. *indica* Fritsch *ex* De, Proc. roy. Soc., Lond., B, 127: 125; 1939 (*nomen nudum*).

Pl. 73, Fig. 2

Thallus thin, gelatinous, blue-green; trichome commonly densely or irregularly aggregated, more or less contorted, moniliform, apical cell rounded, or subconical, apex obtuse; cells generally 2–3 μ broad, as long as broad, spherical or barrel-shaped, sometimes up to 1½ times as long as broad, about 3.5 μ (in immature spores?); heterocysts rare, commonly single, intercalary, spherical, 3.5–5.5 μ broad, commonly isolated, exospore solid, endospore thin.

In rice-field soils, Faridpur, Bengal (Fritsch, *loc. cit.*; also De, 1939).

Fritsch draws a comparison between this alga and the genus *Isocystis* and says that further work is needed to establish the relationship between the two genera.

### 6. **Anabaena fertilissima** Rao, C. B.

The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 363, fig. 6A–C, 1937b.

Pl. 74, Fig. 1

Trichome single, straight or bent, with almost rounded end cells, up to 350 μ long, 5–5.6 μ broad, at the apex 4 μ broad; cells barrel-shaped, 4.8–8 μ long; heterocysts almost spherical, 6.4–8.4 μ broad; spores in long chains, often making the whole trichome sporogenous, adjoining the heterocysts but formed centrifugally, almost spherical, with a smooth hyaline outer wall, 4.8–8 μ broad and 3.2–8.8 μ long.

In ponds, Benaras (Rao, *loc. cit.*), Nallabari, Kamrup, Assam (Parukutty, 1939, 233), in paddy-fields of U.P. and Bihar (Singh, R. N., 1942d, 743) and in a tank at Bandra, Bombay (Gonzalves and Joshi, 1946, 168).

Parukutty records this alga with a greater range of dimensions — cells 4.5–6.6 μ broad, 4.5–6 μ long; heterocysts 4.5–9 μ broad, 4–6.6 μ long; spores 6.6–11 μ broad and 5.5–8.8 μ long.

### 7. **Anabaena gelatinicola** Ghose

A systematic and ecological account of a collection of blue-green algae from Lahore and Simla, J. Linn. Soc., Bot., Lond., 46: 341, pl. 31, fig. 8, 1924.

Pl. 76, Fig. 6

Thallus thick, gelatinous; trichome mostly solitary, spirals densely arranged and coiled, not screw like, sometimes straight; cells subspherical,

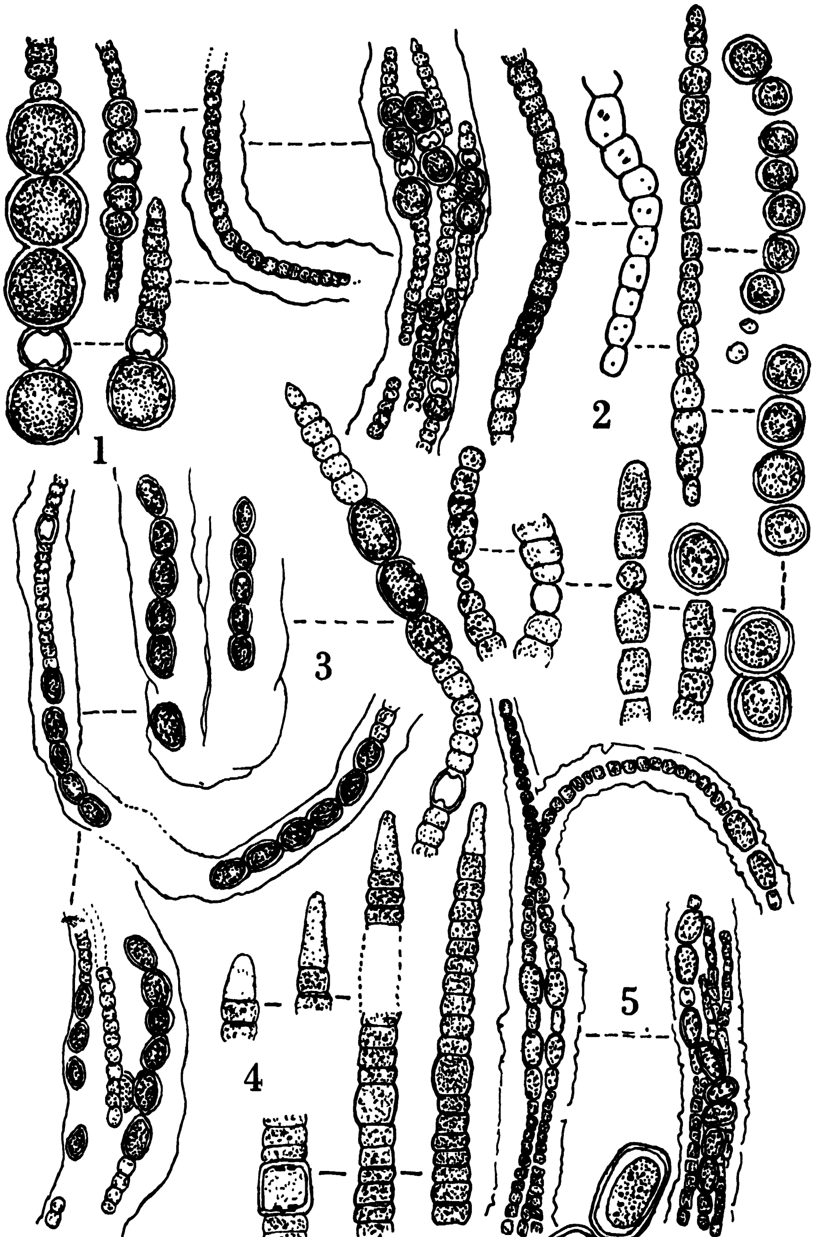

PLATE 73, Figs. 1–5.

1. *Wollea bharadwajae* forma (after Prasad); 2. *Anabaena anomala* Fritsch (after Fritsch); 3. *A. vaginicola* v. *fertilissima* Prasad (after Prasad); 4. *A. torulosa* forma (after Fritsch); 5. *A. vaginicola* Fritsch et Rich (after Fritsch and Rich).

6–7.5 μ broad, apex acute; heterocysts 7–8 μ broad, spherical; spores in series, away from the heterocyst, spherical, about 14 μ diam.

On moist grounds (Ghose, *loc. cit.*).

Geitler (1932, p. 900) considers this as a form of *A. variabilis*. Fritsch (1949, p. 153) lays emphasis on the importance of the spore as a diagnostic character. The present species has in addition spherical heterocysts.

### 8. **Anabaena ambigua** Rao, C. B.

A new species of *Anabaena* (*Anabaena ambigua* ap. nov.), Proc. Indian Acad. Sci., B, 5: 101, figs. 1, 2, 1937.

= *Wollea ambigua* (Rao) Singh, R. N., Ann. Bot., Lond., n. s. 6: 606, 1942.

Pl. 76, Fig. 2

Trichomes free or completely enclosed in a mucilaginous envelope or sheath; in the latter case occurring singly or in group; trichomes without sheaths free-floating, ensheathed trichomes free-floating or attached to host by one end, generally occurring single, but occasionally in dense clusters; sheath usually firm, hyaline, with smooth or rough outline; usually 300–500 μ (rarely up to 1 mm) long, 10–50 μ broad; trichomes straight, or bent, usually slightly tapering at the ends, with end cells having rounded apices; usually 250–300 μ long, sometimes longer; cells barrel-shaped with deep constrictions at the joints, septa indistinct, 4.9–6.6 μ broad, 3.5–5 μ long, cell contents deep blue-green, and coarsely granular; heterocysts at intervals, almost spherical, sometimes with slightly flattened ends, usually broader than the cells, 6.4–9 μ (rarely up to 10 μ) in diam.; spores formed in free trichomes as well as in those enclosed in a sheath one on each side of the heterocyst, usually ellipsoidal, sometimes cylindrical, with rounded ends or occasionally flattened ends, 8.4–10.9 μ broad and 13.3–16.2 μ long, exospore thick and hyaline, endospore thin and transparent.

Free-floating or attached to submerged plants in a pond, Benaras (Rao, *loc. cit.*); paddy-fields in U.P. and Bihar (Singh, R. N., 1942d, 743), in rice-field soil from Siwait near Allahabad (Mitra, 1951, 359).

Singh, R. N. (1942b) transfers this species to *Wollea* as *W. ambigua* (Rao) Singh on account of the presence of sheath around the trichomes. The habit of one or more filaments getting enclosed in a mucilaginous sheath is commonly found in a number of species of *Anabaena* and it would be unrealistic to transfer all these forms to *Wollea*. The essential character of *Wollea* is the presence of finger-like thalli which grow attached erect and this is not seen in these different species and Geitler (1942, p. 184) and Fritsch (1945, p. 825; 1949, 151–153) are against such a transfer.

### 9. **Anabaena vaginicola** Fritsch et Rich

Contributions to our knowledge of the freshwater algae of Africa, 7. Freshwater Algae from Girqualand West. Trans. roy. Soc. S. Afr., 18(1): 87, 1929.

= *Anabaenothrix vaginicola* (Fritsch and Rich) Ghose and Randhawa in Randhawa, Proc. Indian Acad. Sci., B, 3: 407, 1936.

Pl. 73, Fig. 5

Trichomes many in a common mucilaginous sheath, rarely single, more or less parallel, 4–4.5 μ broad, single trichome with sheath 11.5 μ broad, many trichomes in a sheath, 17–21 μ broad, attached to other plants; cells subquadrate, to elongate cylindrical; apical cell acuminate conical; heterocysts cylindrical, 4–5 μ broad, 6–10 μ long, spores short cylindrical or oblong, contiguous with the heterocysts, often 4–5 in series, wall hyaline, 6.5–10 μ broad and 12–17.5 μ long.

Type not recorded.

### f. **fertilissima** Prasad

Some Nostocaceae from Uttar Pradesh, J. Indian bot. Soc., 31: 361, figs. 14–17, 1952.

Pl. 73, Fig. 3

Plant mass soft, pâle-green, entangled with angiospermic roots, interspersed in the thallus of *Vaucheria* sp., trichomes shining blue-green, rarely free, commonly one or several anchored in a diffluent mucilaginous sheath; cells quadratic barrel-shaped 4.8–5.6 μ broad, 3.2–5.6 μ long, constricted at the cross-walls; heterocysts barrel-shaped, slightly flattened at the apices, 6.6–7.2 μ broad and 5.5–6 μ long; spores ellipsoidal, 6.4–8 μ broad and 11.2–13.4 μ long, developed centripetally in long chains, sporulation commencing away from the heterocyst but gradually progressing towards them, often a whole filament becoming sporogenous; spores sometimes placed obliquely or transversely in the filament.

River Barna, Benaras (*loc. cit.*).

### 10. **Anabaena fuellebornii** Schmidle

Engler's Bot. Jahrb., 32: 61, pl. 1, fig. 4, 1892; Forti in De Toni, Sylloge Algarum, 5: 449, 1907; Frémy, Myxo. d'Afr. équat. franc., 367, fig. 305, 1929; Geitler, Kryptogamenflora, 904, fig. 567e, 1932.

Pl. 71, Fig. 11 and Pl. 75, Figs. 1, 3

Trichomes forming a small floccose, mucilaginous, blue-green mass, coiled or straight, sheath diffluent, seldom single; cells cylindrical with rounded

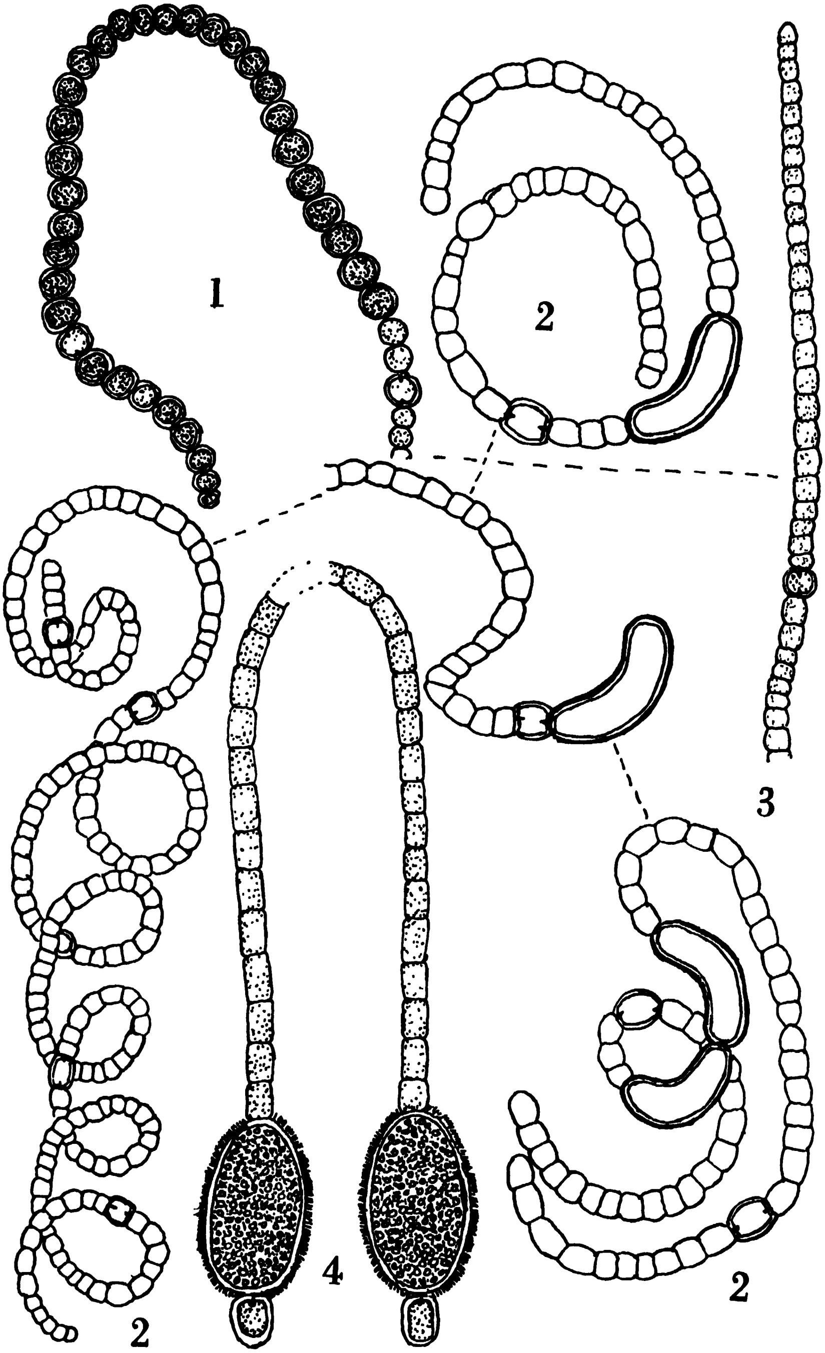

PLATE 74, Figs. 1–4.

1, 3. *Anabaena fertilissima* Rao, C. B. (after Rao, C. B.); 2. *A. utermöhlii* (Uterm.) Geitler (Orig.); 4. *Cylindrospermum gorakhpurense* Singh, R. N. (after Singh, R. N.).

ends, 4–5 μ broad, mostly somewhat longer than broad, up to 10 μ long, seldom up to ¾ as long as broad, end cell rounded; heterocysts barrel-shaped or cylindrical with rounded ends, (5.5–) 7 μ broad and 10 (7–12) μ long; spores on one side of the heterocyst, single or in pairs, ellipsoidal or cylindrical, somewhat swollen on the sides, about 10 (–16) μ broad and 20 (–34) μ long, epispore yellowish with fine papillae.

In pools and tanks.—Borivali and Bandra near Bombay (Gonzalves and Joshi, 1943a, 37; 1946, 168); Mandalay in Burma (Skuja, 1949, 40).

Skuja (1949) describes the Burmese alga in great detail. The description of the species given here is after Skuja's description.

### 11. **Anabaena volzii** Lemm.

Über die von Herrn Dr. Walter Volz auf seiner weltreise gesammelte Süsswasseralgen, Abh. Nat. Ver. Bremen, 18: 153, pl. 9, figs. 4, 5, 20, 1906; Forti in De Toni, Sylloge Algarum, 5: 449, 1907; Geitler, Kryptogamenflora, 901, 1932.

= *A. unispora* Gardner, New Myxophyceae from Porto Rico, Mem. N. Y. bot. Gdn, 7: 59, pl. 12, fig. 8, 1927.

Pl. 77, Fig. 1

Trichome single, free-swimming bent or curved, seldom very straight, without a mucilaginous sheath, 4–5.5 μ broad, constricted at the cross-walls; cells cylindrical, 7–12 μ long, end cell conical, rounded; heterocysts nearly cylindrical, 5.5–7 μ broad, 12–15 μ long; spores single, ellipsoidal, on one side of the heterocyst, 15–21 μ broad and 32–33 μ long, with a smooth colourless membrane.

Singapore (Lemmerman's); Banks of River Yamuna, Allahabad (Gupta, 1956, 77).

Drouet (Bull. Torrey bot. Cl., 64: 601, 1937) and Fritsch (1949, 150) are of the opinion that *Anabaena unispora* and *A. volzii* are identical.

Rao, C. B., (1937b, 362) describes a variety under *A. volzii*, var. *crassa* (Rao) Fritsch (= var. *crassa* (Rao) Bourrelly, Algues d'eau douce du Soudan Francais, region du Macina (A.O.F.). Bull. de l'I I.F.A.N., 19: ser. A. no. 4, 1049, pl. 21, fig. 186, 1957) (= *A. unispora* var. *crassa* Rao, *see* Pl. 15, Figs. 4, 6) which differs only slightly from the type (Fritsch, 1949, 155).—Trichome broader than the type, 4.8–6.6 μ broad, 500–700 μ long, cells 4.5–13.2 μ long, heterocysts 5–8.2 μ broad and 7.4–16.5 μ long; spores narrower 9.6–15 μ broad, and 23–31.5 μ long, epispore hyaline. The variety resembles very much, especially in the spores, f. *recta* Kisselev (Acta Univesitat. Asiac Mediae, ser. 12a, Geographica Taschkent, fasc. 9, 74, pl. 1, fig. 1, 1931; Elenkin, Monogr. Cyano., pars spec., 1: 773, 1938) — cells 4–5 μ broad and 7–14 μ long,

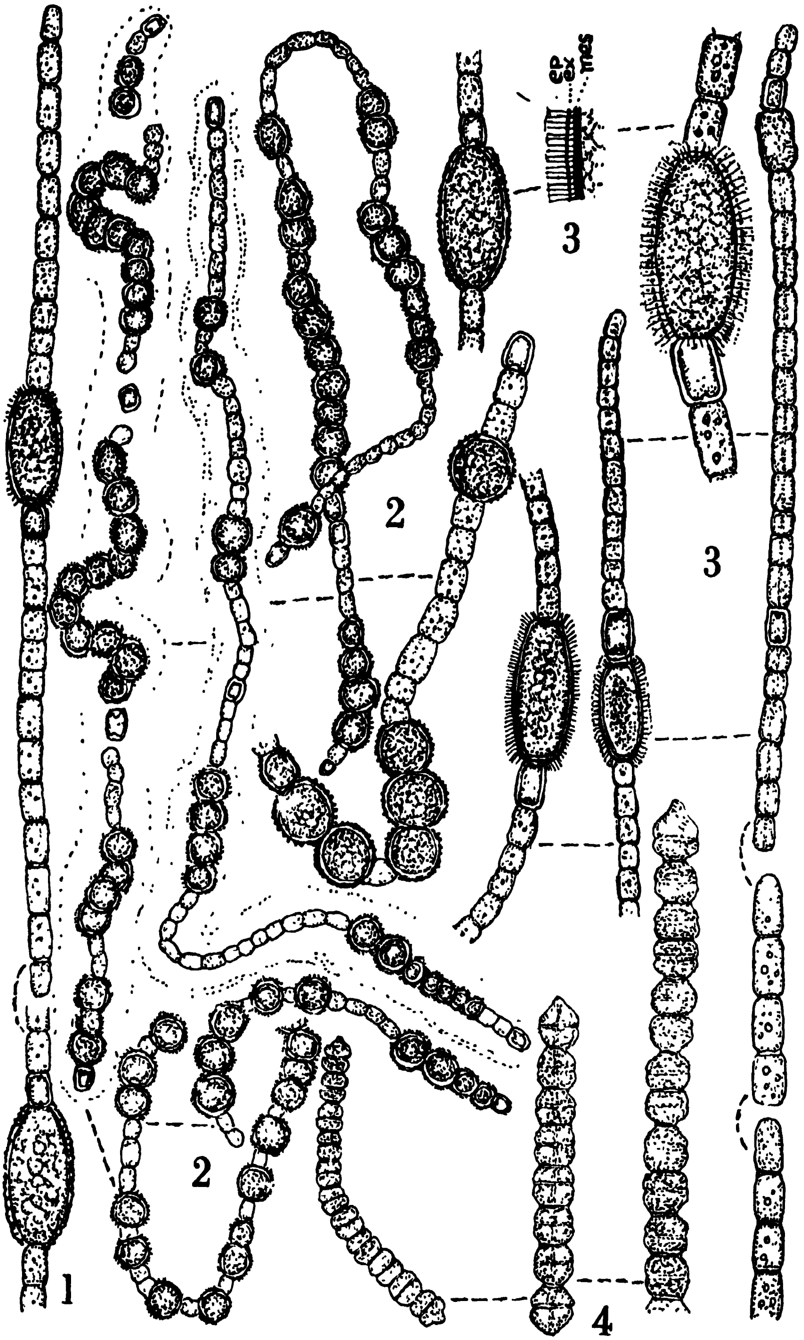

PLATE 75, Figs. 1–4.

1, 3. *Anabaena fuellebornii* Schmidle (after Skuja); 2. *A. khannae* Skuja (after Skuja); 4. *Pseudanabaena schmidlei* Jaag (after Skuja).

heterocysts 5–6 μ broad and 8–14 μ long, spores 10–16 μ broad and 24–35 μ long. Var. *crassa* (Rao) Fritsch is also known from a pool at Vandalur near Madras ( ! ) and near Shembagadevi falls near Courtallam ( ! ).

### 12. **Anabaena aphanizomenoides** Forti

Atti Mem. ac. d'agric. Sc. lett. arti e comm. Verona, ser. 4, 12: 126, fig. 2, 1912; Geitler, Kryptogamenflora, 875, fig. 556, 1932.

Pl. 71, Fig. 4

Trichome single, straight or slightly bent, 1–2 mm long, 4–5 μ broad, slightly constricted at the cross-walls; cells barrel-shaped, cylindrical, 1–3 times as long as broad, with gas-vacuoles; heterocysts subspherical or ellipsoidal, 5.5–7 μ broad, 6–7.5 μ long; spores single or a few near the heterocysts, spherical, 8–14 μ broad, with smooth colourless wall.

In a tank, Madras ( ! )

In the Madras alga the heterocysts are only about 4.5 μ broad and the spores about 7 μ broad and 10.5 μ long.

### 13. **Anabaena beckii** De Toni G. B.

Noterella di nomenclatura algologica, 3, 1935.

= *Anabaena indica* Beck in Beck, G. de and Zahlbruchner, A., Shedae ad ' Kryptogamas exsiccatas ' editae a Museo Palatino Vindobonensis, Ann. de K. K. Naturhist. Hofmuseums, 12: 82, 1897, *non* Zeller.

= *Anabaena sphaerica* var. *indica* (Beck) Biswas, Rec. bot. Surv. India, 9 (2): 59, 1949.

Thallus floccose or mucilaginous, free-floating blue-green or greenish; trichome filiform, 3.7–5 μ broad, straight or curved, without sheath; cells spherical, truncate or subquadrate; heterocyst, globose or oval, 6–7.4 μ broad, rarely 10 μ long; spores continguous with the heterocyst, centripetal formation, abundantly formed, spherical to oval, 14.8–17.3 μ broad × 12.3–13.5 μ long, first blue-green later olive-green, epispore thick.

In marshes near Dadar in Bombay (Beck and Zahlbruchner, *loc. cit.*).

### 14. **Anabaena orientalis** Dixit

The Myxophyceae of the Bombay Presidency, I, Proc. Indian Acad. Sci., B, 3: 101, fig. 3D, E, 1936.

Pl. 77, Fig. 6

Trichome single, straight or slightly curved, 2.5–4 μ broad, cells quadrate or cylindrical, rarely slightly barrel-shaped, up to twice (or even thrice) as long as broad, 3.7–4.8 μ long, end-cell conical with rounded apex; heterocysts single, intercalary, cylindrical or slightly ellipsoidal with rounded end-walls, 4.8–5.5 μ broad, and 7.4–9.2 μ long; spores one on each side of a heterocyst, ellipsoidal, 7.4–9.2 μ broad and 14.8–16.6 μ long.

In a rainwater pool, near sea coast, Mahaluxmi, Bombay (Dixit, *loc. cit.*); Hot springs (34°C), Vajreshwari, Bombay (Gonzalves, 1947, 25).

### Var. **ellipsospora** (Rao, C. B.) comb. nov.

= *Anabaena aphanizomenoides* var. *ellipsospora* Rao, C. B., Myxophyceae of the United Provinces III, Proc. Indian Acad. Sci., B, 6: 362, fig. 5F, G, 1937b.

Pl. 78, Figs. 8, 9

Trichomes 3.3–4 μ broad, apical cell 1.6 μ broad, cells 3.3–11 μ long; heterocysts 6–6.6 μ broad and 6–11.6 μ long; spores one or two together on either side of the heterocyst, 9.6–13.5 μ broad and 11.6–19.8 (–23) μ long.

In a rainwater pool, Benaras (Rao, C. B., *loc. cit.*).

Fritsch (1949, p. 153) has correctly stated that Rao's alga is perhaps more appropriately be referred to *A. orientalis*. An account of the difference in the dimensions of the alga it is retained as a variety.

### 15. **Anabaena Iyengarii** Bharadwaja

The Myxophyceae of the United Provinces, I, Proc. Indian Acad. Sci., B, 2: 105, fig. 6H-K, 1935.

Pl. 78, Fig. 2

Trichome single or irregularly curved, 5.2–6.3 μ broad, end-cell conical with rounded apex; cells barrel-shaped, as long as broad, or slightly shorter or longer than broad; heterocysts barrel-shaped, rarely spherical, 7.3–8.4 μ broad and 7.3–10.5 μ long; spores ellipsoidal often in long or short chains, rarely single on both sides of the heterocysts, 8.4–10.5 μ broad and 10.5–21 μ long, epispore thick, smooth and yellowish brown.

Among other algae in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*) and McPherson lake, Allahabad (Gupta, 1956, 77).

Singh, R. N. (The Myxophyceae of the United Provinces IV, Proc. Indian Acad. Sci., B, 9: 67, 1939b) describes a form — trichomes 4.8–6.2 μ broad; cells 3.4–4.5 μ long; heterocysts 6.6–7.4 μ broad and 8-11 μ long; spores in pairs 13.2–14 μ broad and 15–20 μ long — floating on the surface of water in a paddy-field, Gorakhpur.

Rao, C. S. (The Myxophyceae of Bihar Province I, Proc. Indian Acad. Sci., B, 9: 148, 1938) describes a form — trichomes 3.5–4 μ broad; cells 3–4 μ

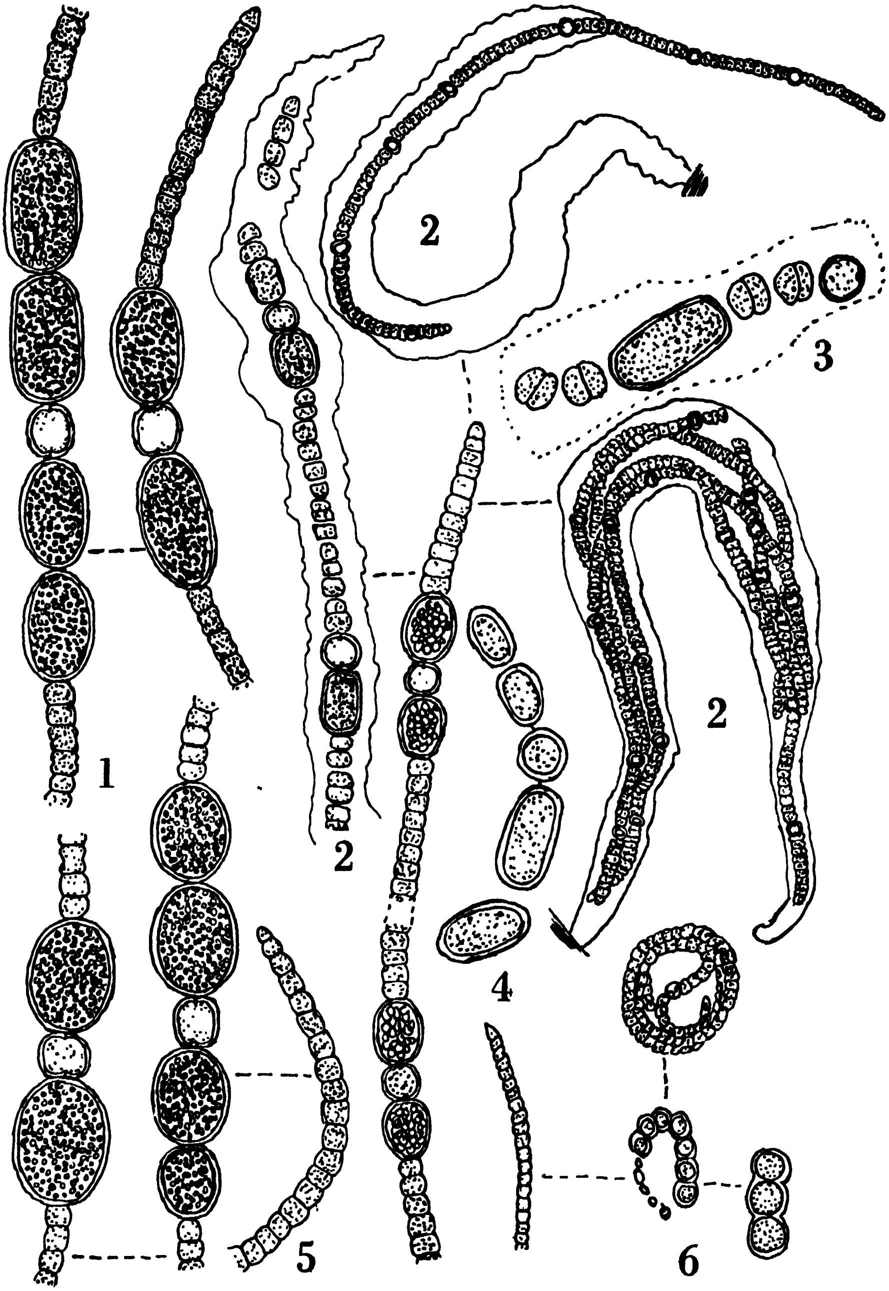

PLATE 76, Figs. 1–6.

1. *Anabaena iyengarii* v. *tenuis* Rao, C. B. (after Rao); 2. *A. ambigua* Rao, C. B. (after Rao); 3. " *Anabaenothrix epiphytica* Ghose et Randhawa " (after Randhawa); 4. " *A. cylindrica* Ghose & Randh." (after Randhawa); 5. *Anabaena iyengarii* v. *attenuata* Rao, C. B. (after Rao, C. B.); 6. *A. gelatinicola* Ghose (after Ghose).

long; heterocyst 4 μ broad, and 4.5–5.4 μ long; spores in chains, 4.7–8 μ broad and 9.1–14.8 μ long — free-floating in a pond, Dharbanga.

Var. **tenuis** Rao, C. B.

The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 361, fig. 5A-C, 1937b.

Pl. 76, Fig. 1

Plant mass floccose, thin, free-floating, pale blue-green; trichomes single, straight or irregularly curved, 3.5–4.5 μ broad, end cells conical with rounded apices; cells barrel-shaped, as long as broad, or slightly shorter than or longer than broad, (2.5–) 3–6.4 μ long; heterocysts more or less barrel-shaped, sometimes spherical, 4.8–6.4 (–8) μ broad and 5.2–9 (–12) μ long; spores ellipsoidal, or cylindrical, with rounded ends, single or in pairs on either side of a heterocyst, 7.5–9.6 μ rarely 10.5 μ broad and 9–19 μ rarely 21 (–24) μ long, with a smooth hyaline outer wall.

In a pond, Benaras (Rao, C. B., *loc. cit.*); in a tank, Delhi (Rao, C. S., 1940, 127); and on moist soil, Yamuna Tank, Allahabad (Gupta, 1956, 77).

Var. **attenuata** Rao, C. B.

The Myxophyceae of the Orissa Province, Proc. Indian Acad. Sci., B, 8: 163, fig. 2A-C, 1938b.

Pl. 76, Fig. 5

Plant mass mucilaginous, deep blue-green; trichomes single, straight or irregularly curved, tapering at the ends, 4–4.2 μ broad, at the apex 1–1.5–2 μ broad; cells barrel-shaped, as long as broad or shorter or longer than broad, 3–6.4 μ long; heterocysts barrel-shaped, 5–6 μ broad and 6–9 μ long; spores ellipsoidal, single or in pairs, on either side of the heterocyst, 11.7–15.6 μ broad and 15.4–19.5 μ long, with a smooth hyaline wall.

In a puddle, Cuttack (Rao, *loc. cit.*); in a fountain, New Delhi (Rao, C. S., 1940, 148).

Var. **unispora** Singh, R. N.

The Myxophyceae of the United Provinces IV, Proc. Indian Acad. Sci., B, 9: 67, fig. 1E, 1939b.

Pl. 78, Figs. 5, 7

Plant mass mucilaginous, deep blue-green; trichomes single, free-swimming, straight, 3.3–4.2 μ broad, with a conical apical cell, possessing almost rounded apex; cells barrel-shaped, or almost quadratic, 3.3–5 μ long, heterocysts barrel-shaped, rarely spherical, 4.5–6.6 μ broad and 6.6–8.2 μ long;

spores ellipsoidal or subspherical, one on either side of the heterocyst, 13.2–16.5 μ broad and 16.5–20 μ long, with smooth and rust coloured inner wall.

Floating on the surface of a paddy-field, Gorakhpur (R. N. Singh, *loc. cit.*).

| | Species Type | forma Singh | forma Rao | V. *tenuis* | V. *attenuata* | V. *unispora* |
|---|---|---|---|---|---|---|
| Trichome μ Br. | 5.2–6.3 | 4.8–6.2 | 3.5–4 | 3.5–4.5 | 4–4.2 | 3.3–4.2 |
| Cell length μ | as long as | 3.4–4.5 | 3–4 | 3–6.4 (–7.5)<br>(2.5–4.5) | 3.6–5 | 3.3–5 |
| Apex | conical rounded | × | × | as in species | attenuated 1.5–2 | same as species |
| Heterocyst | Barrel-shaped | | | | | |
| Br. × μ | 7.3–8.4 | 6.6–7.4 | 4 | 4.6–6.4 (–8) | 5–6 | 4.5–6.6 |
| l. | 7.3–10.5 | 8–11 | 4.5–5.4 | 4.8–12 | 8–9 | 6.6–8.2 |
| Spores | chains | pairs | chains | single or in pairs on either side ellipsoidal or cylindrical | single or in pairs ellipsoidal | single on either side ellipsoidal and sub-spherical |
| Br. × μ | 8.4–10.5 | 13.2–14 | 4.7–8 | 7.5–9.6 (–10.5) | 11.7–15.6 | 13.2–16.5 |
| l. | 10.5–21 | 15–20 | 9.1–14.8 | 9–19.5 (–21) | 15.4–19.5 | 16.5–20 |
| | 1935 | 1939 | 1939 | 1937 | 1938 | 1938 |

It appears as though this species is a highly variable one and differentiation of subordinate taxa difficult.

### 16. **Anabaena ballyganglii** Banerji

Studies on the Myxophyceae of Lower Bengal, II, J. Dept. Sci., Calcutta Univ., 1 : 98, fig. 2a-d, 1938.

Pl. 77, Fig. 4

Trichomes fragile, circinate, never straight, forming a thin pale blue-green stratum over the surface of a small water pond; cells compressed, spherical as long as broad or slightly shorter or longer than the diameter, 7–8.5 μ broad and 6.5–13.5 μ long, contents granular; heterocysts somewhat spherical with homogeneous contents, single or in pairs; trichomes often break up into hormogones just where the heterocysts are in pairs with one heterocyst at each end, 7.5–10 μ broad and 7.5–11 μ long; spores single, ellipsoidal, younger ones somewhat spherical, remote from the heterocyst, wall of the spore thick, smooth, colourless, contents granular.

Planktonic forming a scum in a stagnant pond, Ballygunge, Calcutta (*loc. cit.*).

### 17. **Anabaena naviculoides** Fritsch

The genus *Anabaena* etc., J. Indian bot. Soc., 28: 138, figs. 17-39, 1949.

Pl. 72, Fig. 2

Thallus thin, gelatinous, blue-green; trichome elongate, more or less coiled, moniliform, apices acuminate; cells 3.5–5 μ broad, as long as or shorter than broad (developing akinetes), apical cell obtuse conical, or acute, sometimes retuse; heterocysts rare, intercalary, single, barrel-shaped, 5–6 μ broad, as long as or slightly longer than broad; spores in long series, irregularly disposed, ellipsoidal, ends acute and protracted, exospore thin, hyaline, more or less 11–12.5 μ long, 6–7 μ broad and 8.5–9 μ long × 5.5 μ broad.

In rice fields, Faridpur, Bengal (Fritsch, *loc. cit.*, De, 1939, 125).

### 18. **Anabaena doliolum** Bharadwaja

The Myxophyceae of the United Provinces, I, Proc. Indian Acad. Sci., B, 2: 105, fig. 6A, D, 1935.

Pl. 78, Fig. 3

Plant mass mucilaginous, pale blue-green; trichome single, free-swimming, straight, curved or slightly coiled, 3.6–4.2 μ broad, slightly tapering at the ends, with conical apical cell, possessing almost pointed apex, cells barrel-shaped, as long as broad or a little longer or shorter than broad; heterocysts barrel-shaped, 5.2–6.3 μ broad and 6.3–9.4 μ long; spores ellipsoidal, with almost pointed apices in short or long chains, adjoining the heterocysts but developed centrifugally, epispore thick, smooth and hyaline or yellow brown, 4.2–6.2 μ broad and 6.3–11.5 μ long.

Among other algae in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

### 19. **Anabaena variabilis** Kützing ex Born. et Flah.

Kützing, Phyc. gene., 210, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 226, 1888; Forti in De Toni, Sylloge Algarum, 5:

437, 1907; Frémy, Myxo. d'Afr. équat. franc., 360, fig. 294, 1929; Geitler, Kryptogamenflora, 876, fig. 558, 1932.

= *A. indica* Zeller, Algae collected in Arracan etc., J. Asiatic. Soc, Bengal, 42: 1873a, *non* Beck.

Pl. 71, Fig. 5

Thallus gelatinous, dark-green; trichome without any sheath, flexuous, 4–6 µ broad, more often 4.2–5 µ broad slightly constricted at the cross-walls, end-cells conical, obtuse; cells barrel-shaped, sometimes with gas-vacuoles, 2.5–6 µ long; heterocysts spherical or oval, 6 µ broad, up to 8 µ long; spores formed centrifugally, not contiguous with the heterocysts, barrel-shaped, in series, 7–9 (–11) µ broad, 8–14 µ long, epispore smooth, or with fine needles, colourless or yellowish brown.

On brackish mud, on damp soil, in stagnant pools, streams and rivers.—Akyab, Ye-tho-choung stream, Pegu (Zeller, 1873a, 180; 1873b, 171; Theobald, 1883, 23), and Rangoon (Ghose, 1927b, 241) in Burma; Simla (Ghose, 1924, 341); Thana near Bombay (Dixit, 1936, 101); Calcutta and River Hooghly near Calcutta (Banerji, 1938, 100; Biswas, 1942, 198); Lahore in Pakistan (Ghose, 1924, 341; Singh, H. D., 1933, 106).

The heterocysts in the Indian material are 4.5–7.5 µ broad and 6–8 µ long. Ghose (1927b, 241) reports this alga from Rangoon and according to him the spores were immature (5–6 µ broad and 6–7 µ long). Fritsch (1949, 144) thinks that this probably is not a *A. variabilis* on account of the short akinetes.

Rao, C. B. (1936, 171) reports a form of this species which differs from the type in the thinner trichomes, cylindrical spores and heterocysts of variable dimensions — trichomes 2.5–6 µ broad, cells 2.5–6 µ long, heterocysts 4.5–7.1 µ broad and 6.3–9.6 µ long, spores 6–8.5 µ broad and 6.5–11.5 µ long. Fritsch (1949, 155) considers this as not very different from the type.

Var. **ellipsospora** Fritsch

The genus *Anabaena* etc., J. Indian bot. Soc., 28, 142, figs. 40–50, 1949.

Pl. 72, Fig. 1

Thallus thin, gelatinous, blue-green, trichome slightly flexuous, loosely aggregated, constricted at the cross-walls, apical cells rounded, sometimes conical or obtuse; cells 4–4.5 µ broad, generally elongate, 5.5–9 µ long, cylindrical or slightly barrel-shaped, sometimes later isodiametrical and torulose or moniliform; heterocysts intercalary, solitary, spherical or barrel-shaped, 5.5–6 µ broad, and 5–8 µ long, heterocysts rarely terminal, hemispherical; spores in catenate series, away from the heterocysts, ellipsoidal, more or less oblong, 5–7 µ broad and 7.5–12 µ long, endospore thin, exospore separated from the endospore, indurated over a part of its surface only.

In rice field soils, Faridpur (De, 1939; Fritsch, *loc. cit.*).

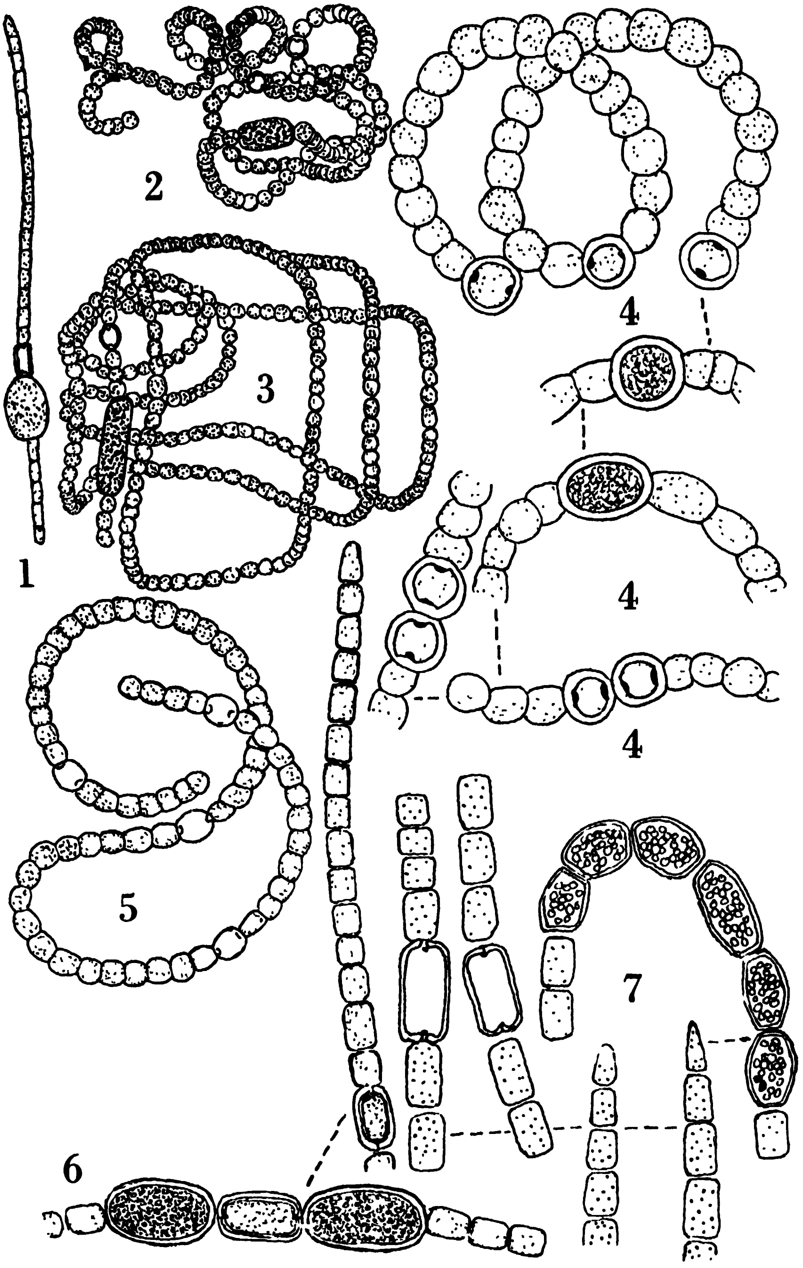

PLATE 77, Figs. 1–7.

1. *Anabaena volzii* Lemm. (as *A. unispora* Gardner) (after Gardner); 2. *A. circinalis* Rabenh. (after Smith); 3. *A. circinalis* v. *macrosperma* (Wittr.) Forti (after Smith); 4. *A. ballygunglii* Banerji (after Banerji); 5. *A. circinalis* v. *crassa* Ghose (after Ghose); 6. *A. orientalis* Dixit (after Dixit); 7. *A. variabilis* v. *kashiensis* (Bharadw.) Fritsch (after Bharadwaja).

### Var. **kashiensis** (Bharadwaja) Fritsch

The genus *Anabaena*, J. Indian bot. Soc., 28: 155, 158, figs. 88–92, 1949.

= *A. kashiensis* Bharadwaja, Myxophyceae of the United Provinces, I, Proc. Indian Acad. Sci., B, 2: 105, fig. 6C-G, 1935.

Pl. 77, Fig. 7

Thallus dense, soft, mucilaginous, deep green; trichomes 3.1–4.2 µ broad, blue-green, often irregularly curved and more or less entangled with each other, slightly constricted at the joints, attenuated at the ends, the terminal cell being conical with a sharp or rounded apex, without mucilaginous sheath; cells cylindrical, up to twice as long as broad, rarely barrel-shaped, and almost as long as broad; heterocysts single intercalary, and distributed at regular intervals throughout the length of the trichome, cylindrical, 4.2–5.2 µ broad and 8.4–12.6 µ long; spores in short or long chains, ellipsoidal or barrel-shaped, remote from the heterocyst, 4.2–6.3 µ broad and 6.3–10.5 µ long, with a thick, smooth and colourless outer wall.

On floating dead leaves in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

### 20. **Anabaena laxa** (Rabehn.)

A. Br., in Bornet and Flahault, Bull. Soc. bot. Fr., 32: 120, pl. 4, figs, 2, 3, 1885; Revision des Nostocacées hétérocystées, 233, 188.

= *Anabaena inaequalis* (Kütz.) Bornet and Flahault, Revision des Nostocacées hétérocystées, 231, 1888; Forti in De Toni, Sylloge Algarum, 5: 446, 1907; Frémy, Myxo. d'Afr. équat. franc., 365, fig. 301, 1929; Geitler, Kryptogamenflora, 896, fig. 578, 1932. *non* Cooke, 1884.

= *A. oblonga* Wildemann, Ann. Jardin Buitenz., 1: 50, 1897.

= *A. kuetzingiana* De Toni, J., Noterelle di nomencl. algol. 8: 2, 1936.

Thallus floccose, free-floating or attached to other algae, blue-green; trichomes 4–5 µ broad, straight, parallel, sometimes free and sometimes with a mucilaginous sheath; cells spherical or barrel-shaped, 5–6 µ long, apices hardly attenuated, end-cell rounded; heterocyst spherical, 6 µ broad, or elongate and up to 10 µ long; spores single or many away from the heterocyst, 6–8 µ broad, and 14–17 (–20) µ long; episporc smooth and yellowish.

In stagnant water, Rangoon, Burma (Ghose, 1926, 249; 1927e, 79); in a brackish water pond and Hambantota, Ceylon (Crow, 1923b, 143); in soil, Lahore (Singh, H. D., 1933, 106); on moist soil near McPherson Lake, Allahabad (Gupta, 1956, 77).

Fritsch's (1949, 155) circumscription of the species *A. inaequalis* is accepted here. *A. inaequalis* (Kütz.) Born. and Flah., is preceded by *A. inaequalis* Cooke 1884 and De Toni renames the former as *A. kuetzingiana.* In the sense of present circumscription *A. laxa* and *A. oblonga* precede *A. Kuetzingiana.* Hence *A. laxa* is accepted here.

### 21. **Anabaena circinalis** Rabenhorst ex Born. et Flah.

Algen Eur. Exs., no. 209, 1852; Fl. Eur. Alg., 2: 183, 1865; Bornet and Flahault, Revision des Nostocacées hétérocystées, 230, 1888; Forti in De Toni, Sylloge Algarum, 5: 443, 1907; Geitler, Kryptogamenflora, 981, fig. 572a, 1932; Frémy, Cyano. cotes d'Eur., 184, pl. 61, fig. 3, 1933.

= *A. circinalis* (Kütz.) Hansg., Öst. bot. Zeitschr., 34: 390, pl. 1, figs. 12–14, 1884.

= *A. flos-aquae* var. *circinalis* Kirchn., Kryptogamenflora von Schlesien, 2(1): 235, 1878.

Thallus frothy, floating; trichome mostly circinate, seldom straight, mostly without a sheath, 8–14 μ broad; cells barrel-shaped or spherical, somewhat shorter than broad, with gas-vacuoles; heterocysts subspherical, 8–10 μ broad; spores cylindrical, sometimes curved, ends rounded, 16–18 μ broad up to 34 μ long, ordinarily away from the heterocyst epispore smooth and colourless (Pl. 77, fig. 2).

Plankton in standing waters, Bengal (Biswas, 1927, 51).

*Anabaena circinalis* Rabenh., (1865) was first described as *Cylindrospermum circinalis* Rabenh. Kützing (1945) has similarly described a *Cylindrospermum circinalis* which Hansgirg (1884) transferred to *Anabaena. Anabaena hassallii* (Kütz.) Wittr., (1882) (= *Cylindrospermum hassallii* Kütz. 1849), is often included in *Anabaena circinalis* Rabenh. *Anabaena circinalis* Rabenh. has been accepted by Bornet and Flahault (1888), and their circumscription of the species to include all the other species is generally accepted. Elenkin (1938, p. 738; also Lemmermann, 1910, p. 186) however recognises *Anabaena hassallii* (Kütz.) Wittr., and includes under it *Anabaena circinalis* Rabenh., and also recognises *A. circinalis* (Kütz.) Hansg. as an independent species.

#### Var. **crassa** Ghose

On some Myxophyceae from Rangoon, J. Burma Res. Soc., 15: 249, pl. 6, fig. 14, 1926.

Pl. 77, Fig. 5

Trichome free-swimming, single, semi-circular, loosely coiled up to 4 times; cells nearly spherical, but generally shorter than broad, 5–7 μ in diameter, with pseudovacuoles; heterocysts globose, up to 8 μ broad; spores not seen.

In stagnant ponds, Rangoon (Ghose, *loc. cit.*).

According to Fritsch (1949, 155) this is not distinct from the type.

### 22. **Anabaena flos-aquae** (Lyngb.) Bréb. ex Born. et Flah.

Brébisson, in Bréb. et Godey, Algues des environs de Falaise, 36, 1835; Bornet and Flahault, Revision des Nostocacées hétérocystées, 228, 1888; Forti in De Toni, Sylloge Algarum, 5: 441, 1907; Frémy, Myxo. d'Afr. équat. franc., 362, fig. 297, 1929; Geitler, Kryptogamenflora, 890, fig. 571a, b, 1932.

Thallus frothy, gelatinous, lubricous, free-floating, bluish in colour; trichomes circinate, 4–8 μ (commonly 5.5 μ) broad, without sheath; cells ellipsoidal, seldom spherical, as long as broad or longer, 6–8 μ long, mostly with gas-vacuoles; heterocysts ellipsoidal, 4–9 μ broad and 6–10 μ long; spore prominently bent, on the outside convex, on the inside straight, 7–13 μ broad, mostly 9 μ, 20–35 μ rarely 50 μ long, single near the heterocyst or seldom away from it, epispore smooth, colourless or yellowish, often surrounded by a wide gelatinous sheath.

Planktonic.—Hlein River near Byn-Dor-Engi and Khyoung-gyi in the Irrawaddy, Burma (Zeller, 1873a, 180; Theobald, 1883, 23); Mont Lake near Colombo, Ceylon (Skvortzow, 1928, 109); River Hooghly near Calcutta (Biswas, 1942, 198); in a pool in Madras ( ! ).

### 23. **Anabaena utermöhlii** Geitler

in Pascher's Süsswasserflora, 443, 1925; Kryptogamenflora, 884, 1932.

= *A. spiroides* v. *minor* Uterm., Arch. Hydrobiol. (u. Planktonk.) suppl. 5: 380, 1925.

Pl. 74, Fig. 2

Trichomes single, free-floating, often regularly, sometimes irregularly spirally coiled; spirals 17–30 μ (commonly up to 23 μ) broad, and up to 40 μ (ordinarily 27–37 μ) distant, sometimes uncoiled; cells 4–4.5 μ broad, 4–6.5 μ long, often with gas vacuoles; heterocysts somewhat elongate, 4–4.5 μ broad, 4.7–5.7 μ long; spores bent, on both sides of the heterocyst, 7–8 μ broad, 19–20 μ long, epispore smooth and colourless.

In a pool, Madras ( ! ).

The cells in the Madras alga were 3.9–5.2 μ broad, 3.9–9.2 μ long, the heterocysts 5.2–7.2 μ broad, and the spores 5.2–6.6 μ broad and 18.3–23.6 μ long.

### 24. **Anabaena torulosa** (Carm.) Lagerh. ex Born. et Flah.

Bidrag till Sveriges Algflora, K. Vet. Akad. Forh., 40(2): 47, 1883; Bornet and Flahault, Revision des Nostocacées hétérocystées, 236, 1888; Forti in De Toni, Sylloge Algarum, 5: 455, 1907; Myxo. d'Afr. équat. franc., 370, fig. 306, 1929; Geitler, Kryptogamenflora, 887, fig. 567d, 1932; Frémy, Cyano. cotes d'Eur., 186, pl. 62, fig. 1, 1933.

Pl. 71, Fig. 6

Thallus mucilaginous, thin, blue-green; trichome 4.2–5 μ broad, apical cell acutely conical; cells barrel-shaped, as long as or somewhat shorter than

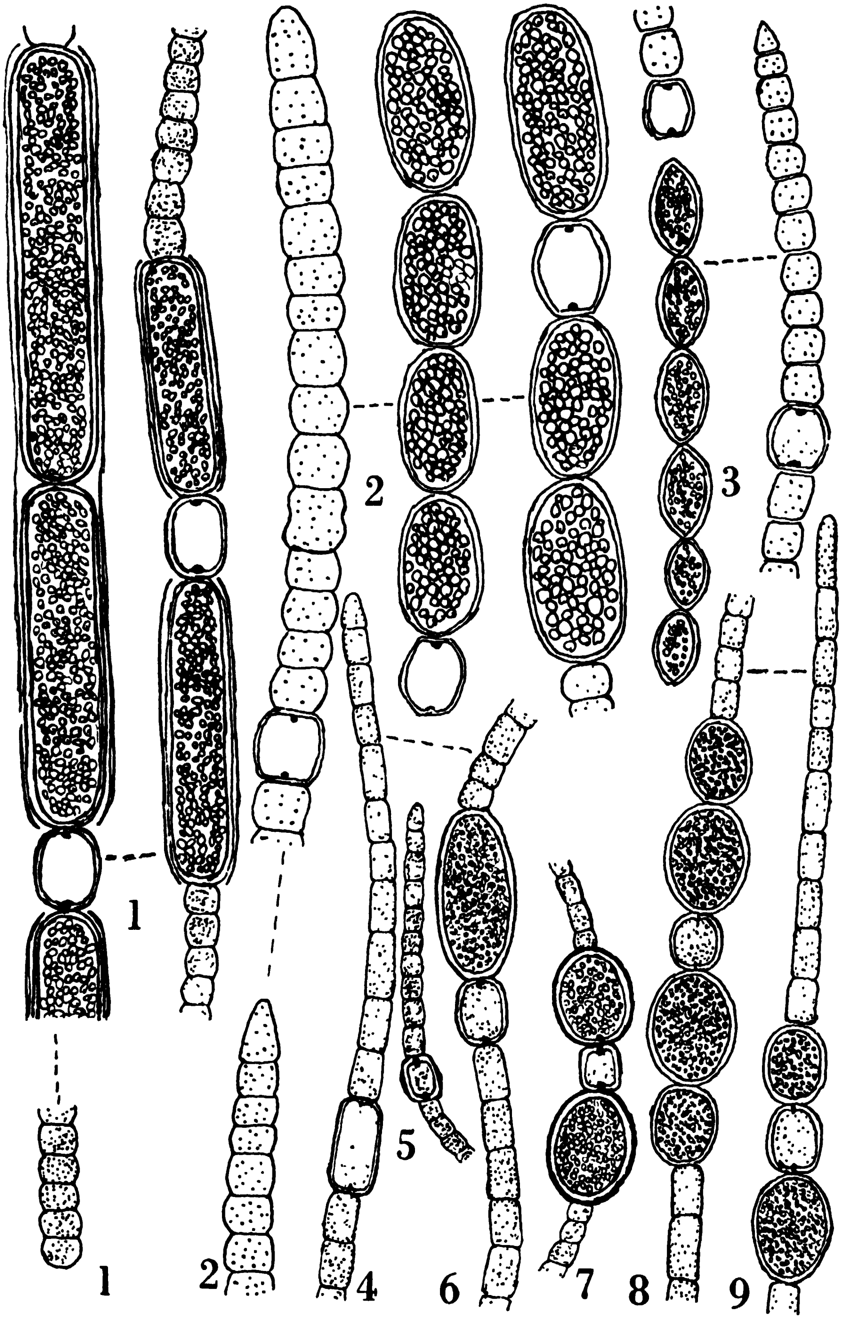

PLATE 78, Figs. 1–9.

1. *Anabaena oscillarioides* v. *angustus* Bharadw. (after Bharadwaja); 2. *A. iyengarii* Bharadw. (after Bharadwaja); 3. *A. doliolum* Bharadw. (after Bharadwaja); 4, 6. " *A. unispora* v. *crassa* Rao, C. B." (after Rao, C. B.); 5, 7. *A. iyengarii* v. *unispora* Singh, R. N. (after Singh R. N.); 8, 9. *A. aphanizomenoides* v. *ellipsospora* Rao, C. B. (after Rao).

broad; heterocysts subspherical or ovoid, 6 μ broad and 6–10 μ long; spores on both sides of the heterocysts, developed centripetally, single or many, subcylindrical with rounded ends, sometimes constricted in the middle, 7–12 μ broad, up to twice as long as broad, epispore smooth and pale brown in colour.

Floating after detaching from submerged plants, Chilka Lake, Orissa (Biswas, 1932b, 187); roadside ditch, Panihati near Calcutta (Banerji, 1938, 100); near Rangoon and Kyauktan (Skuja, 1949, 43).

Lemmermann (1910, 190) first suggested the possibility of *A. torulosa* being a saltwater form of *A. oscillarioides*. Canabaeus (1929, 36) suggests that the presence of a median waist is not valuable as a taxonomic character. Geitler (1932, 887) feels that these two are the same. Elenkin (1938, p. 748) includes it under *A. oscillarioides*. Fritsch (1949, 145) is of the view that not withstanding these above observations the species can still stand on their other characters such as the distinctive end-cells, usually shorter vegetative cells, seemingly shorter spores with broad flat ends instead of rounded ends.

Fritsch (The genus *Anabaena*, J. Indian bot. Soc., 28: 144, figs. 51–59, 1949) describes a form (Pl. 73, Fig. 4) — heterocysts commonly barrel-shaped; cells 3.5–4 μ broad; apical cell markedly elongated and attenuated; akinetes cylindrical, 7–8.5 μ broad and 11–14 μ long, exospore thick and firm—from rice-field soils from Faridpur (see also De, 1939, 125).

### 25. **Anabaena oscillarioides** Bory ex Born. et Flah.

Bory, Dict., class. d'hist, nat., 1 : 308, 1822; Bornet and Flahault, Revision des Nostocacées hétérocystées, 233, 1888; Forti, in De Toni, Sylloge Algarum, 5 : 451, 1907; Frémy, Myxo. d'Afr. équat. franc., 371, fig. 307, 1929; Geitler, Kryptogamenflora, 886, fig. 567e, 1932; Frémy, Cyano. cotes d'Eur., 185, pl. 61, fig. 5, 1933.

Pl. 71, Fig. 7

Thallus gelatinous, dark green, trichome 4.2-6 (generally 5–6) μ broad; cells barrel-shaped as long as broad, or somewhat longer or shorter than broad, end cells rounded; heterocysts spherical or oval, 6–8 μ broad, 6–10 μ long; spores on both sides of the heterocysts; single or 2–3, at first oval, later rounded — cylindrical, 8–10 μ broad (more commonly 10 μ), 20–40 μ long, epispore smooth and pale brown.

In rice-fields near Sadiyar (Carter, 1926, 268) and in temporary rainwater pools, Borivli near Bombay (Gonzalves and Joshi, 1943a, 37) in Royal lakes, Rangoon (Skuja, 1949, 43).

Parukutty (1939, 233) recorded a form from Assam (in ponds attached to dead vegetable matter, Nalbari, Kamrup), which differs in the smaller heterocysts and shorter spores (cell 4.9–6.6 μ broad, 5–6.8 μ long; heterocysts 6–10 μ broad and 5.5–10.5 μ long; spores 6.6–12 μ broad and 15–26.5 μ long).

### Var. **angustus** Bharadwaja

The Myxophyceae of the United Provinces I, Proc. Indian Acad. Sci., B, 2: 103, fig. 5 D-F, 1935.

Pl. 78, Fig. 1

Trichomes single, irregularly bent or spirally coiled 4.2–5.2 μ broad; end cell rounded; cells barrel-shaped, as long as or slightly shorter or longer than broad; heterocysts intercalary, very rarely terminal, ellipsoidal, 5.2–6.3 μ broad and 7.3–10.5 μ long; spores long, cylindrical, single or in short or long chains, on both sides of the heterocysts, 6.5–8.4 μ broad and 14.7–41.0 μ long, epispore smooth yellow-brown.

Among other algae in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

According to Bharadwaja, the variety is distinguished by a narrower filaments, ellipsoidal heterocysts and by narrower spores which may be in long chains, with yellowish brown outer wall and surrounded by a mucilaginous sheath. Parukutty's forma (1939, p. 233) and the type between themselves have the characteristics described for the variety. Fritsch (1949, 155), probably rightly, feels that this variety is not very distinct from the type.

## SPECIES REJECIENDAE

*Anabaena hansgirgi* Schmidle (1900b, 185)

on tree trunks, Matheran, near Bombay (cf. Fritsch, 1949, p. 135).

*Anabaena* (*Sphaerozyga*) *nordstedtii* Turner (1892, 13)

fresh water algae from North India (Cf. Fritsch, 1949, 155).

*Anabaena allahabadii* Mitra, A. K. (1951, 359)

from rice-field soils, Siwait, Allahabad (*nomen nudum*).

*Anabaena moniliforme*( ! ) Randhawa (1936c, 37)

N. India Randhawa, *loc. cit.*

*Anabaena bullosa* Kütz.

recorded by Zeller (1873a, 180; also *see* Theobald, 1883, 23) in mud at Bala-choung, Po-swondoung, Toung-nigoo, Taittoung Valley, Burma ( = *Hapalosiphom laminosus* Hansg. cf. Born. et Flah., 1883, 240).

*Anabaena subtilissima* Kütz.

on mud in tidal creeks, Rangoon (Zeller, 1873b, 180) (cf. Born. et Flah., 1883, 239).

## **PSEUDANABAENA** Lauterborn

Sapropel. Lebenwelt., Verh. Naturw. Verein. Heidelb., 13: 437, 1914–1917.

Trichome single, not forming a thallus, with cells distinctly placed from one another, with brisk creeping movements, without sheath; cells cylindrical and at the ends rounded or oval.

Lectotype: *P. catenata* Lauterb.

Lauterborn created this genus with two species, *P. constricta* (Szafer) Lautb., and *P. catenata* Lauterb. The former was originally described as an *Oscillatoria* and is now commonly included under *Anabaena* (*see* Geitler, 1925, p. 312; 1932, p. 874; Elenkin, 1938, 695; Pl. 71, Figs. 1–3).

Geitler (1942, p. 222) places this genus in " Anhang " at the end of the Oscillatoriaceae. The probability that these forms may represent heterocystless condition of some other Nostocaceae may have to be borne in mind (*see* Geitler, 1942, p. 223).

### KEY TO THE SPECIES

1. Trichome 2 μ broad ........................................ 1. *P. catenata* (p. 419)
1. Trichome broader ........................................ 2. *P. schmidlei* (p. 419)

### 1. **Pseudanabaena catenata** Lauterb.

Lauterborn, *loc. cit.*; Geitler, Kryptogamenflora, 932, fig. 596, 1932.

Cells cylindrical, at both ends truncated, blue-green, sometimes somewhat brownish, 2 μ broad and 3 μ long.

Free-floating in lakes and ponds, Rangoon (Skuja, 1949, 44); planktonic in Nuwarawewa tank in Ceylon (Holsinger, 1954, 9).

### 2. **Pseudanabaena schmidlei** Jaag. O

Die Kryptogamenflora des Rheinfalls und des Hochrheins von Stein bis Englisau, Mitt. Naturf. Ges. Schauffhausen, 14: 1938.

Pl. 75, Fig. 4

Trichomes 6–7 μ broad, up to 300 μ long; cells more or less as long as broad, after division about ½ diam.

Free-floating and on *Limnanthenum nymphaeoides,* Rangoon in Burma (Skuja, 1949, 44).

### f. **robusta** Skuja

Zur Süsswasseralgenflora Burmas, 45, fig. 18, 1949.

Trichome up to 11 μ broad and up to 150 μ long; cells 4–8 or up to 13 μ long.

### f. **gracilis** Skuja

*loc. cit.*, 45, fig. 17, 1949.

Trichome 3.5–4 μ broad, and 50–136 μ long.

## RAPHIDIOPSIS Fritsch et Rich.

Contributions to our knowledge of the Freshwater Algae of Africa, Trans. roy. Soc. S. Afr., 18: 91, 1929.

Trichomes short, more or less bent, without sheath, attenuated at one or both ends, ends pointed with a mucilaginous or solid gelatinous bristle; heterocysts absent; spores present.

Type species: *R. curvata* Fritsch et Rich.

Fritsch and Rich (*loc. cit.*) placed this genus in the *Rivulariaceae* and it probably bears the same relationship as *Raphidonema* and *Microthamnion* to the Chaetophorales. While the attenuated and pointed ends show some resemblance to Rivulariaceae, yet the genus possesses features which resemble very much the planktonic Nostocaceae, like *Anabaenopsis raciborskii, A. aphanizomenoides* etc. The structure of the apices described for *Raphidiopsis curvata* is not shared by the other species. It is more appropriate to place the genus in the Nostocaceae. Geitler (1942, pp. 176, 179) has already transferred the genus to the Nostocaceae and it is followed here.

*Raphidiopsis* as defined by Fritsch and Rich is a non-heterocystous genus. This alga is known from many parts of the world. Skuja (1937), Frémy (1938), Singh (1942) and Rao, K. V. N. (1947) have failed to observe any heterocysts. Drouet (1938) records this alga from Brazil. In one of the collections (Wright, 2022) Drouet observed that many trichomes had at one end a hyaline refringent body which resembled a heterocyst. He observes, " If it is a true heterocyst — and more satisfactory material than that at hand it will be necessary to prove this point beyond doubt — the affinities of the genus with the Rivulariaceae should become evident." Whether the hyaline refringent body which Drouet saw was a heterocyst or not it is doubtless true that the true identity of Wright's specimen will have to be sought elsewhere in the Nostocaceae. But Drouet (1951, p. 164) goes further and transfers the genus to the Nostocaceae and writes " In *Raphidiopsis* the trichome bears at one end a heterocyst; at the other end the cells are narrowed to a sharp point." Drouet does not give any additional evidence for the presence of the heterocyst nor has the diagnosis of the genus been amended.

### KEY TO THE SPECIES

1. Trichomes often curved or spirally coiled .................. 1. *R. curvata* (p. 422)
1. Trichomes generally straight.
    2. Trichomes constricted at the cross-walls; cells 6–8 times as long as broad; spores 3–3.4 × 7.8–9.2 μ .......................... 2. *R. indica* (p. 422)
    2. Trichomes constricted at the cross-walls; cells up to 2–4 times as long as broad; spores 2.5–3.5 × 6.5–13.5 μ................. 3. *R. mediterranea* (p. 422)

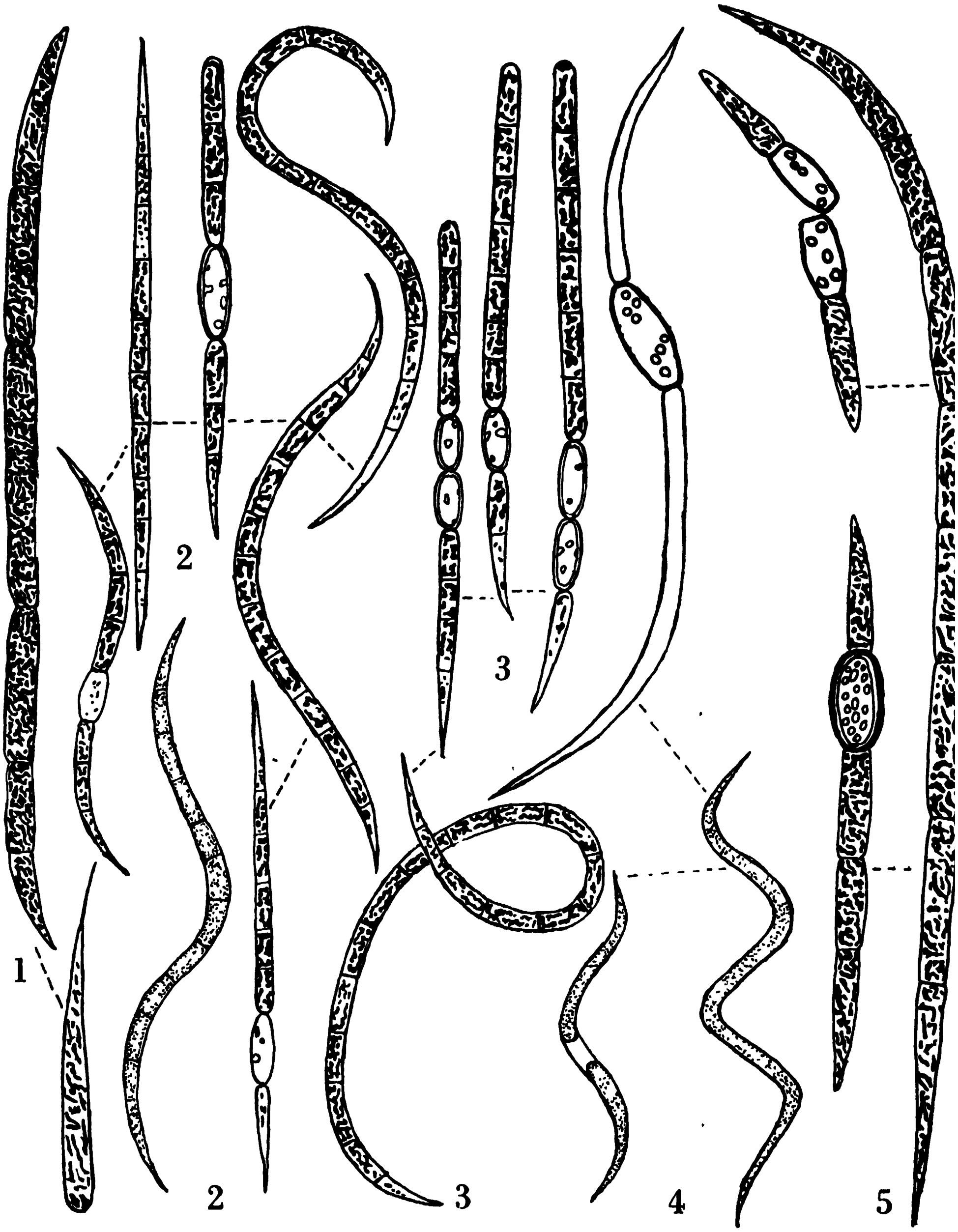

PLATE 79, Figs. 1–5.

1, 5. *Raphidiopsis indica* Singh, R. N. (after Singh); 2, 3. *R. mediterranea* Skuja (after Ra K. V. N.); 4. *R. curvata* Fritsch et Rich (Orig.).

### 1. **Raphidiopsis curvata** Fritsch et Rich

*loc. cit.*, 91, fig. 32, 1929; Geitler, Kryptogamenflora, 658, fig. 120, 1932.

Pl. 65, Figs. 5, 7 & Pl. 79, Fig. 4

Trichome free-floating, single or seldom in bundles, sigmoid or semicircularly bent, seldom very straight, not constricted at the cross-walls; cells often with gas-vacuoles; 1½–2 times as long as broad, 4.5 μ broad; spores barrel-shaped, 10–13.5 μ long, 5 μ broad, in the middle of the trichome.

In a tank, A. H. Gardens, Madras ( ! ).

The Madras form is narrower (2.6–3.9 μ broad) and its spores are 3.9–5.2 μ broad and 10.5–16.1 μ long.

Holsinger (1954, 18) describes a form from the Nuwarawewa tank, Ceylon — trichome narrower, 2 μ diam., cells 4–10 μ long, cell contents homogenous, occasionally with pseudo-vacuoles.

### 2. **Raphidiopsis indica** Singh, R. N.

A new species of the genus *Raphidiopsis* Fritsch and Rich, J. Indian bot. Soc., 21: 239–243, figs. 1–11, 1942.

Pl. 79, Figs. 1, 5

Trichomes single, straight or sometimes curved in a circular or semicircular or sigmoid form, short, made of about 12 cells, occasionally longer, often attenuated, ends pointed, very often fragmented, when the ends are rounded, constricted at the cross-walls, 1.8–2.6 μ broad, cells 6–8 times as long as broad, with gas-vacuoles, gas-vacuole rarely absent; spores penultimate formed by the unequal division of the apical cell, single, rarely in pairs, ellipsoidal with rounded ends, 3.3–4 μ broad, and 7.8–9.2 μ long, epispore very thick, smooth and brown, endospore thin and transparent.

Plankton in pond and tanks in Benaras (Singh, *loc. cit.*).

### 3. **Raphidiopsis mediterranea** Skuja

Süsswasseralgen aus Griechland und Kleinasien, Hedwigia, 77: 23, pl. 1, fig. 5, 1937; Frémy, Sur *Raphidiopsis mediterranea* Skuja, Congr. Socs. sav., Savois, 78: 157, 1938.

Pl. 79, Figs. 2, 3

Trichomes free-floating, mostly straight, often curved or weakly sigmoid of 6–12 cells, rarely smaller or larger number of cells, attenuated at both ends, after fragmentation one or rarely both ends rounded, 40–110 μ long, rarely 180 μ long, 1.9–3 μ broad, unconstricted at the cross-walls, cells 2–5 times as long as broad, generally with gas-vacuoles; spores ellipsoid with rounded ends, epispores brown thick and smooth, 2.8–3.4 μ broad and 6.7–9.3 (–13.5) μ long, single or in pairs, subterminal or intercalary.

Fisheries pond, Hyderabad (Rao, K. V. N., 1956, 87).

Holsinger (1954, 18) reports from Beira lake, Ceylon a *Raphidiopsis* which resembles *R. mediterranea.* — Trichomes mostly straight, solitary, free-floating, seldom exceeding 120 μ in length, with both ends terminating in a point or frequently with one end rounded, generally scarcely constricted at the septa although occasional trichomes show marked constriction; cells in the widest part 3–3.2 μ broad always longer than broad, with or without pseudovacuoles and granules; mucilage sheath absent.

Aptekarj (1928; *see* also Elenkin, 1949, p. 1378) has described an *Oscillatoria, O. setigera* which resembles a straight sterile *Raphidiopsis* and has dimensions which are similar to those recorded for some.

## Subfamily AULOSIRAE Bornet et Flahault

Revision des Nostocacées hétérocystées, 180, 1888.

Sheath thin, membranaceous, persistent; filament free or arranged together more or less parallel.

### NODULARIA Mertens

in Jürgens, Algae aquaticae, Dec., 15, nr. 4, 1822; Bornet and Flahault, Revision des Nostocacées hétérocystées, 243, 1888.

Filaments free with a sheath; trichome in vegetative condition extremely uniform in breadth; sheath hyaline, delicate, mucilaginous, sometimes diffluent; cells short, depressed, discoid; heterocysts intercalary, compressed; spore globose, subglobose to discoid, formed singly or in series between the heterocysts, epispore smooth.

Type species: *N. spumigena* Mertens

Only one species known from the region.

**Nodularia spumigena** Mertens ex Born. et Flah.

in Jürgens, Alg. Dec., 15, nr. 4, 1822; Bornet and Flahault, Revision des Nostocacées hétérocystées, 245, 1888; Forti in De Toni, Sylloge Algarum, 5: 443, 1907; Geitler, Kryptogamenflora, 866, fig. 554b, c, 1932; Frémy, Cyano. cotes d'Eur., 181, pl. 60, fig. 4, 1933.

Pl. 80, Figs. 13, 14

Filaments single, free-swimming or mostly forming mucilaginous thallus, straight, bent or spirally coiled, 8–12 μ broad; sheath thin or thick, colourless;

cells short, discoid, ⅓–¼ as long as broad; heterocysts somewhat broader than the vegetative cells; spores in series, seldom one to a few subspherical, 12 μ broad, and 8–9 μ long, epispore yellowish brown.

Among other algae in standing waters or drains. — Benaras (Bharadwaja, 1935, 102), Saharanpur and Buddha Nala, Ludhiana (Randhawa, 1936a, 406; 1936, 37/42).

The Benaras alga has occasionally terminal heterocysts and the spores are smaller.

### Var. **major** (Kütz.) Born. et Flah.

Revision des Nostocacées hétérocystées, 247, 1888; Geitler, Kryptogamenflora, 867, 1932.

Pl. 61, Fig. 12

Filaments 12–18 μ broad; spores depressed, elliptical, 14–15 μ broad and 6–7 μ long.

Washed ashore, Pamban Coast, Shingle island and Hare island (Iyengar and Desikachary, 1944, 54).

### SPECIES REJECIENDA

*Nodularia fertilissima* Randhawa, Proc. Indian Acad. Sci., B, 4: 41, 1936C (*nomen nudum*).

## AULOSIRA Kirchner

Kryptogamenflora von Schlesien, 238, 1878; Bornet and Flahault, Revision des Nostocacées hétérocystées, 256, 1888.

Filaments free, sparse or in fascicles, generally uniformly broad, without differentiation of base and apex; trichomes with sheath, indefinite; heterocysts intercalary; spores often in series, formed near a heterocyst or away from it, cylindrical.

Type species: *A. laxa* Kirchner.

### KEY TO THE SPECIES

1. Thermal ........................................ 1. *A. bombayensis* (p. 426)
1. Freshwater or terrestrial ........................................ 2
    2. Filaments 5–8 μ broad ........................................ 3
    2. Filaments broader ........................................ 5

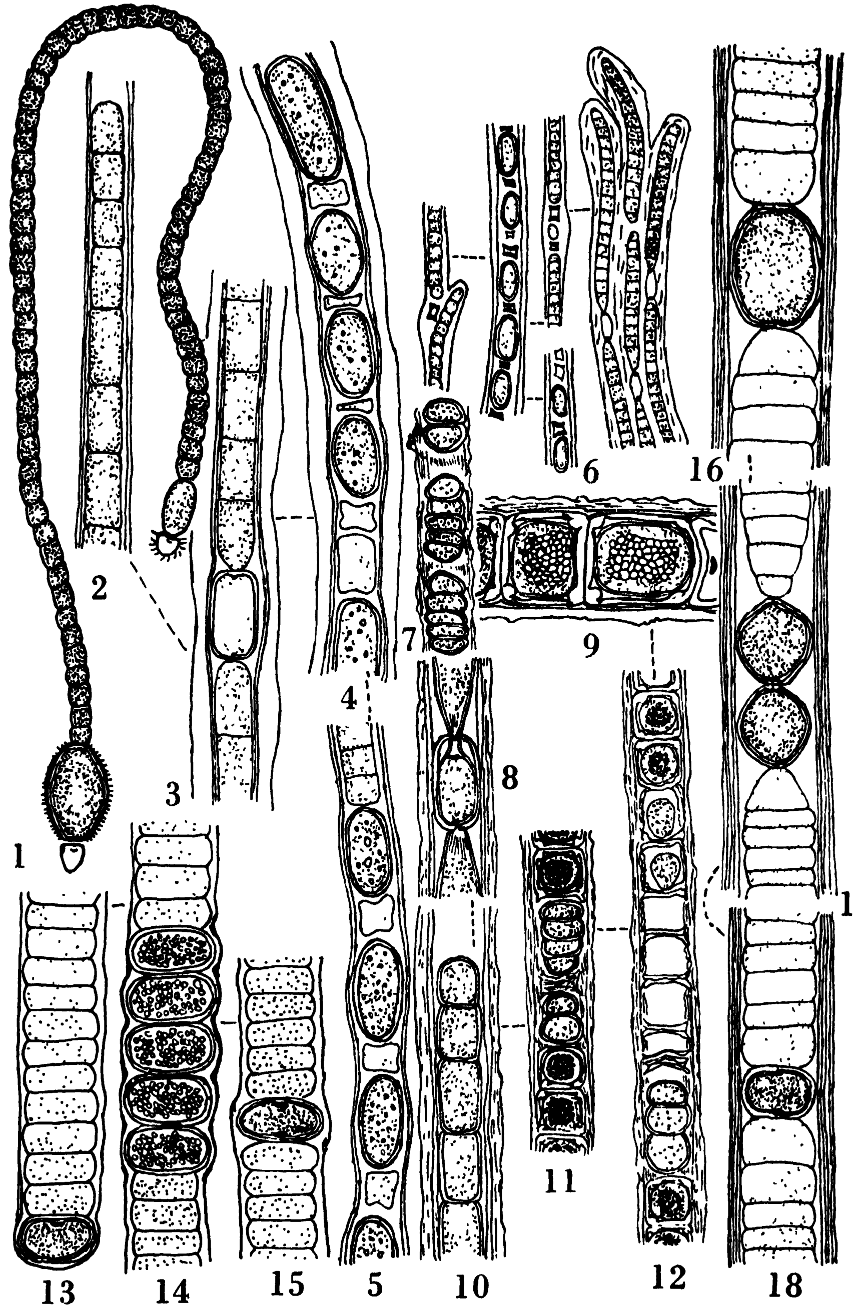

PLATE 80, Figs. 1–18.

1. *Cylindrospermum majus* Kütz. (after Frémy); 2–5. *Aulosira fertilissima* v. *tenuis* Rao, C. B. (after Rao); 6. *A. fertilissima* Ghose (after Ghose); 7–12. *A. fritschii* Bharadw. (after Bharadwaja); 13–15. *Nodularia spumigena* Martens (after Bharadwaja); 16–18. *Aulosira implexa* v. *crassa* Dixit (after Dixit).

3. Trichomes 3.1–5.2 μ broad, spore not seen .............. 2. *A. prolifica* (p. 426)
3. Trichomes broader, spores known .............................................. 4
    4. Trichome 5–5.6 μ broad, spores 7 μ broader, shorter than long 3. *A. aenigmatica* (p. 428)
    4. Trichome 5–7 μ broad, spores 5–7 μ broad and 20–24 μ long 4. *A. laxa* (p. 428)
5. Trichomes less than 10 μ broad, cells cylindrical .............................. 6
5. Trichomes broader ...................................................................... 7
    6. Trichomes 6.3–10.5 μ broad, filaments showing false branching on hormogone germination 5. *A. pseudoramosa* (p. 430)
    6. Trichomes 8–9 μ broad, spores 8–9 μ broad and 16–24 μ long .... 6. *A. implexa* (p. 430)
7. Trichomes 6–11 μ broad, spores 10–13 μ broad and elongate ellipsoidal 7. *A. fertilissima* (p. 431)
7. Trichomes 8.4–10.5 (–12.3) μ broad, spores 10.5–12.6 μ broad, generally quadrate 8. *A. fritschii* (p. 432)

### 1. **Aulosira bombayensis** Gonzalves

On the structure and the life history of *Aulosira bombayensis* sp. nov. Indian bot. Soc., Prof. M. O. P. Iyengar Comm. Vol., 381–387, figs. 1–3, 1946.

Pl. 82, Figs. 1–12

Filaments forming a thick, tangled felt-like expansion, yellowish to deep blue-green in colour; filaments 4–5.2 μ broad; sheath firm, hyaline, unlamellated; occasionally with single pseudobranches; trichomes constricted at the joints, 2.4–3.2 μ broad; cells two or three times as long as broad, sometimes longer; cell contents blue-green; heterocysts intercalary, oblong with rounded ends, 3.4–5 μ broad and 8–12.8 μ long; spores oblong to quadrate, with rounded ends, 4.6–6.4 μ broad and 6.4–12.8 μ long, occasionally up to 20 μ long.

Attached to the walls of a tank connected to a hot spring at Vajreshwari near Bombay (Gonzalves, *loc. cit.*).

### 2. **Aulosira prolifica** Bharadwaja

Contributions to Our Knowledge of Myxophyceae of India, Ann. Bot., Lond., 47: 131, figs. 5, 6, 1933a.

Pl. 81, Figs. 1–6

Thallus forming a dense mucilaginous scum at first pale brownish green to blue-green or green; filaments 4.8–5.6 μ broad, parallel, straight or slightly curved, becoming brownish or greenish yellow; sheath thin, first homogenous, later with an outer diffluent portion up to 1.75 μ thick, and inner uniformly thick, 1 μ, somewhat firm; trichomes markedly constricted at the cross-walls, apical cells tapering to the rounded apex; cells cylindrical, generally longer than broad, 3.1–5.2 μ broad and 6.3–21.0 μ long, rarely quadrate; heterocysts intercalary or terminal, broader than the trichome, bulging out the

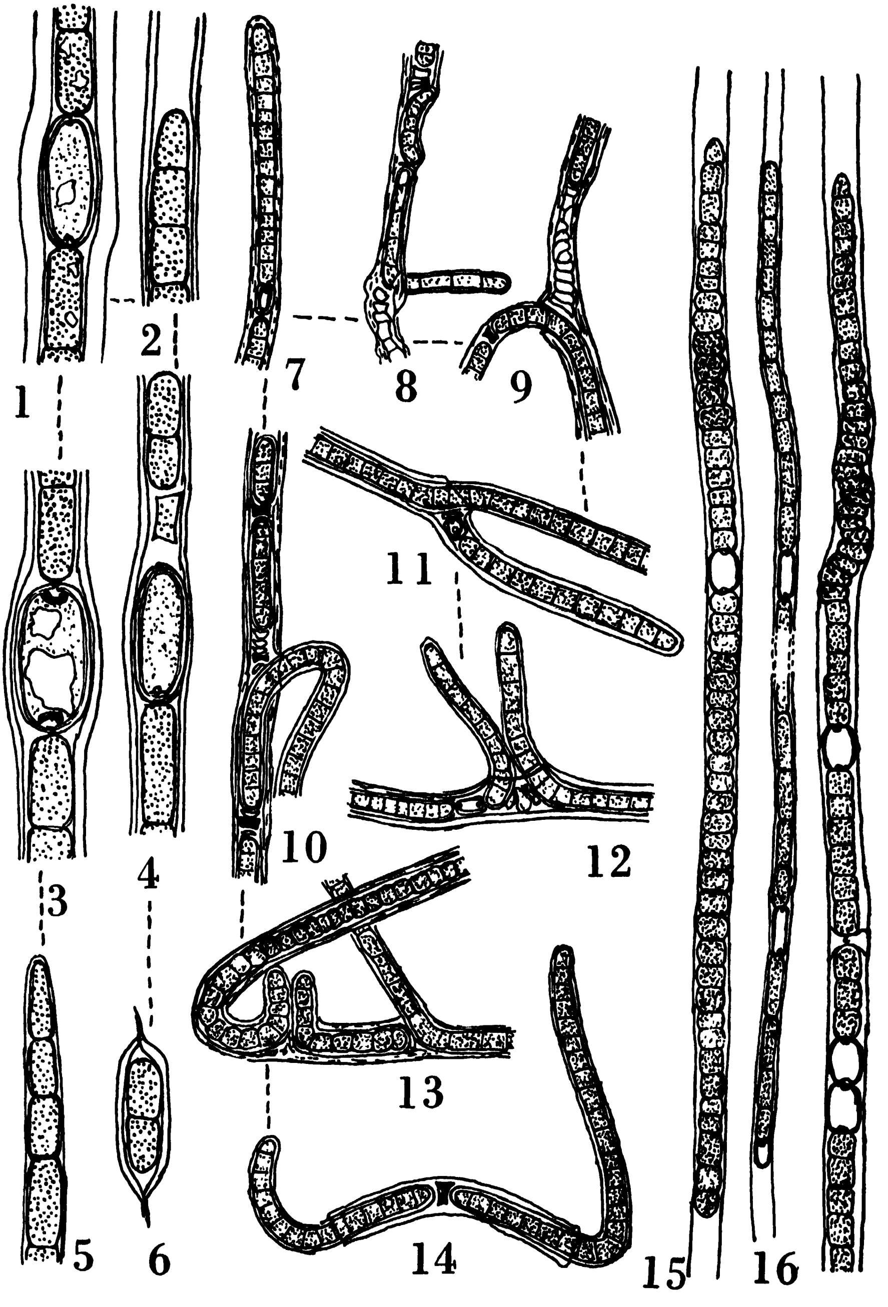

PLATE 81, Figs. 1-16.

1-6. *Aulosira prolifica* Bharadw. (after Bharadwaja); 7-14. *A. pseudoramosa* Bharadw. (after Bharadwaja); 15. *A. aenigmatica* Frémy (after Frémy); 16. *Microchaete aequalis* (Frémy) comb. nov. (after Frémy).

sheath, intercalary heterocysts generally single, rarely in pairs, regularly placed, ellipsoidal, terminal heterocysts at the ends of fragments of trichome, ellipsoidal, oval or subconical, 4.2–8.4 μ broad and (4.8–) 6.4–23.5 μ long; hormogones present; spores not seen; perennation by the fragmentation of the entire filament remaining dormant inside the persistent sheaths.

Forming a dense mucilaginous scum on the surface of the water of a shallow pond, Benaras (Bharadwaja, *loc. cit.*); in a pond at Ellore in Andhra (Rao, C. B., 1938a, 86); Ennore near Madras (!) in a lake at Chingleput, Madras State (!).

### 3. **Aulosira aenigmatica** Frémy

Cyanophycées de l'Inde méridionale, Blumea, Suppl. 2: 37, fig. 11, 1942.

Pl. 81, Figs. 15, 17

Thallus expanded, woolly, dark blue-green floating; filaments more or less intricate, suberect, 6.5–8 μ broad; sheath colourless, close, membranous, thin, not coloured violet with chlor-zinc-iodide; trichome pale blue-green, 5.5–6 μ broad, more or less constricted at the cross-walls; cells subquadrate, longer or shorter than broad, contents finely granular, apical cells attenuated, obtuse conical; heterocysts as broad as or slightly broader than the trichomes, oblong to spherical, single or rarely two; spores variously situated, in series, about 7 μ broad, barrel-shaped or compressed-spherical, commonly shorter than broad, epispore colourless and weakly thick (immature?).

In stagnant waters, Shembaganur, Madras State (Frémy, 1942, 37).

### 4. **Aulosira laxa** Kirchner ex Born. et Flah.

Kirchner, Kryptogamenflora von Schlesien, Algen., 238, 1878; Bornet and Flahault, Note sur la genre *Aulosira* (Bull. Soc. bot. Fr., 32, 120, pl. 4, fig. 1, 1885; Revision des Nostocacées hétérocystées, 256, 1888; Forti in De Toni, Sylloge Algarum, 5: 480, 1907; Geitler, Kryptogamenflora, 674, 1932.

Filaments blue-green, straight or curved, single or fasciculate; sheath thin, delicate, hyaline; trichome 5–8 μ broad; cells barrel-shaped, mostly shorter than broad; heterocysts nearly spherical to cylindrical, 5–8 diam., yellowish; spores cylindrical, 5–7 μ broad and 20–24 μ long.

In lake, Poona (Hansgirg ex Forti in De Toni, 1907, p. 481); Khajiar, Punjab (Gupta, 1950, 110).

Bornet and Flahault did not mention in their Revision whether the spores are formed in series or singly. Lemmermann (1910) and Geitler (1932) mention that they are formed singly; Gupta (*loc. cit.*) states he has observed spores in chains. He however, does not give any figures.

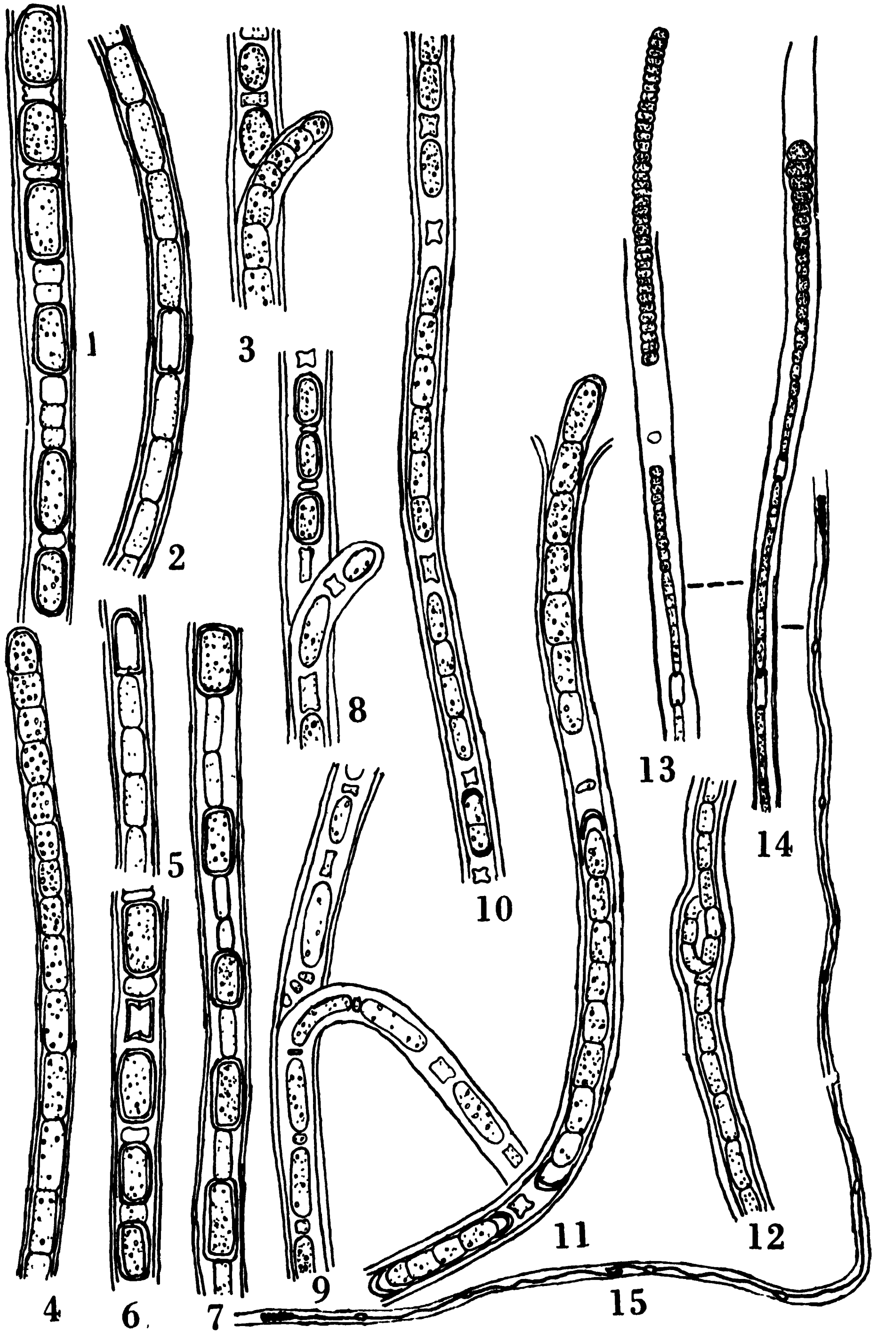

PLATE 82, Figs. 1–15.

1–12. *Aulosira bombayensis* Gonzalves (after Gonzalves); 13–15. *Fortiea bossei* (Frémy) comb. nov. (after Frémy).

### 5. **Aulosira pseudoramosa** Bharadwaja

Contributions to our knowledge of Myxophyceae of India, Ann. Bot., Lond., 47: 137, figs. 7, 9, 1933a.

Pl. 81, Figs. 7–14

Thallus a flat compact system with an uneven surface ordinarily made of unbranched filaments, 9.5–14.7 μ broad, up to 2 mm long, generally irregularly bent, densely entangled; sheath thick, hyaline, parallel, stratified with outer surface uneven, firm, 0.75–2.6 μ thick, when old becoming deep yellow or golden yellow in colour, hard, thick and brittle; trichome constricted at the cross-walls; cells cylindrical, rarely barrel-shaped, usually slightly longer than broad, sometimes as long as broad, rarely shorter, 6.3–10.5 μ broad; cell-contents blue-green, and finely granular; heterocysts absent in young trichomes, intercalary, occurring single, rarely in pairs, terminal ones present, as broad as the trichomes, 6.3–10.5 μ broad and 6.3–18.9 μ long; spore not seen; hormogones one, two or three cells lying dormant in the thick yellowish brown sheath, the filament often breaking into bits or pieces, enclosing one or more hormogones, on germination secreting a thin hyaline sheath, often germinating *in situ* by piercing through the sheath simulating branching in *Tolypothrix*.

Among mosses and liverworts on the wall of a house, Benaras (Bharadwaja, *loc. cit.*); in a pond at Tanuggyi in Burma (Skuja, 1949, 33).

### 6. **Aulosira implexa** Bornet et Flahault

Note sur le genre *Aulosira*, Bull. Soc. bot. Fr., 32: 120, pl. 4, fig. 4, 1885; Revision des Nostocacées hétérocystées, 257, 1888; Forti in De Toni, Sylloge Algarum, 5: 481, 1907; Frémy, Myxo. d'Afr. équat. franc., 380, fig. 318, 1929; Geitler, Kryptogamenflora, 675, fig. 434 b, c, 1932.

Filaments 5–10 mm long, straight or curved, often fasciculate; sheath thin, membranous, hyaline; trichome 8–9 μ broad; cells quadrate, cylindrical somewhat longer or shorter than broad, blue-green, slightly constricted at the cross-walls, granular; heterocysts quadrate to oblong; spores 4–32 in series, 8–9 μ broad, 16–34 μ long, epispore smooth.

Elephant point, Pegu (Kurz in Herb. Grunow, ex. Born. and Flah., *loc. cit.*).

#### Var. **crassa** Dixit

The Myxophyceae of the Bombay Presidency, India — I, Proc. Indian Acad. Sci., B, 3: 98, fig. 2A-D, 1936.

Pl. 80, Figs. 16–18

Filaments straight or slightly curved, 22–25 μ diam.; sheath hyaline, stratified, at first thin, later thick, up to 3.7 μ thick; trichomes 16.8–18.5 μ broad; cells usually broader than long, disc-shaped, rarely almost quadrate, 7.4–11.1 μ long, with slight constrictions at the joints; heterocysts quadratic, disc-shaped or cylindrical; single sometimes two together, 14.8–18.5 μ broad and 7.4–22.2 μ long; spores not seen.

Among other algae on the bed of a rivulet, Borivli, near Bombay (Dixit, *loc. cit.*) and in stagnant water along railway line near Devarai, near Bombay (Gonzalves and Kamat, 1954, 351).

Gonzalves and Kamat (*loc. cit.*, figs. 1–8) recorded a peculiar type of hormogone formation involving the rupture of the inner sheath and a subsequent dissection of the trichome at a number of points by the growing in of these inner layers across the trichome. The neighbouring cells die out and a number of hormogones are formed. The hormogones become independent by the gelatinization of the deflected portion and the filament is broken into a number of pieces.

### 7. **Aulosira fertilissima** Ghose

A systematic and ecological account of a collection of blue-green algae from Lahore and Simla, J. Linn. Soc. Bot., 46: 342, pl. 31, fig. 9, 1924; Geitler, Kryptogamenflora, 675, fig. 435, 1932.

Pl. 80, Fig. 6

Stratum expanded, dark blue-green, membranous; trichomes straight or a little flexuous, parallel or densely intricate, rarely with very short pseudobranches; cells (4–) 6–11 μ broad and (5–) 7–10 μ long, cylindrical when young, later barrel-shaped, contents granular; sheath thick, at first gelatinous and hyaline, later firm and brown; heterocysts intercalary, oblong or elliptical, 8–9 μ broad and 10–14 μ long; spores in series usually alternating with dead cells, generally oblong-elliptical, sometimes angular due to compression 10–13 μ broad and 18–24 μ long.

On decaying leaves of *Nelumbium speciosum* in a water course, Lahore in Pakistan (Ghose, *loc. cit.*); on dead leaves and twigs in a pond in Mandalay, Burma (Ghose, 1931, 35); freshwater algae, Saharanpur (Randhawa, 1936a, 405), in paddy-fields of U.P. and Bihar (Singh, R. N., 1942d, 743), in a tank at Bandra, near Bombay (Gonzalves and Joshi, 1946, 168).

Kisselew (1930; *see* also Geitler, 1932, p. 707; Elenkin, 1938, p. 1209–1210) includes this species under *Scytonematopsis*.

### Var. **tenuis** Rao, C. B.

The Myxophyceae of the United Provinces—III, Proc. Indian Acad. Sci., B, 6: 353, fig. 3F-I, 1937b.

Pl. 80, Figs. 2–5

Plant mass fibrous and greyish blue; filaments free, (4.8–) 5.6–6.4 μ broad, more or less straight, and closely crowded together; sheath thin, firm and brown, 0.3–0.8 μ thick, sometimes enveloped by diffluent mucilage; trichome slightly tapering at the ends 3.3–4.8 (–5.5) μ broad, rarely constricted at the cross-walls; end-cell with a rouned apex; cells cylindrical, sometimes quadrate 3.3–19.8 long; heterocysts cylindrical, with rounded endwalls, broader than the trichome and causing the filaments to bulge, 4.5–7 μ broad and 8.2–19.8 (–23.2) μ long; spores in long chains, ellipsoidal to cylindrical, 4.8–8.8 (–10) μ broad and 10.5–19.2 μ long, intercalated by moribund cells.

In stagnant waters, Benaras (Rao, C. B., *loc. cit.*), Chittavaram and Namdur in Andhra State (Rao, C. B., 1938a, 86) and Berhampur (Rao, C. B., 1938b, 161).

### 8. **Aulosira fritschii** Bharadwaja

Contributions to our knowledge of the Myxophyceae of India, Ann. Bot. Lond., 47: 123, figs. 3, 4, 1933a.

Pl. 80, Figs. 7–12

Thallus dirty blue-green, or dark-green, woolly, felt-like, attached to leaves; filaments unbranched, about 7 mm long, 10–16.5 μ broad, loosely entangled straight or irregularly bent; sheath hyaline, outer portion diffluent, up to about 3.1 μ thick, stained violet by chlor-zinc-iodide; trichome constricted at the cross-walls, 8.4–10.5 (–12.3) μ diam.; cells slightly longer than broad, up to 3–4 times the breadth, cell-contents blue or deep blue-green, finely granular; heterocysts single and intercalary, cylindrical, rarely elongate-cylindrical, slightly longer than broad, sometimes twice as long as broad, (8.2–) 9.4–11.5 (–13.2) μ broad and 14.7–23.5 μ long; spores in long chains formed centrifugally interrupted by vegetative cells, roughly quadratic, (10–) 10.5–12.6 (–13.2) μ in width, some cylindrical up to twice as long as broad, 6.6–33 μ long, exospore thick and pale brown, endospore thin and hyaline.

On dead leaves etc., in a stagnant ponds, etc., Benaras (Bharadwaja, *loc. cit.*; Rao, C. B., 1937b, 353), Ellore and Chittavaram in Andhra State (Rao, C. B., 1938a, 85); Cuttack and Puri (Rao, C. B., 1938b, 162); in a lake Khajiar, Punjab (Gupta, 1950, 111); in a pool at Elliot's beach, Madras ( ! ).

Bharadwaja (1933a, fig. 4) described the germination of the spores.

The Madras alga is slightly larger than the type. — Filaments 10–24 μ diam., trichome 7.1–14.2 μ broad, cells up to 21.4 μ long, heterocysts 10.7–14.2 μ broad and up to 35.6 μ long, spores 10.7–14.2 μ broad and up to 21.4 (–35.6) μ long.

## **HORMOTHAMNION** Grunow

Reise seiner Majestat Fregatte Novara um die Erde, Bot. Theil, 1: Algen, 31, 1867; Bornet and Flahault, Revision des Nostocacées hétérocystées, 259, 1888.

Thallus made of parallel filaments, sometimes forming a mucilaginous expanded layer or filaments sometimes erect, branched without a common mucilage; filaments with a thin membranous often diffluent, colourless sheath; trichomes moniliform; heterocysts intercalary; spores not known.

Type species: *H. enteromorphoides* Grun.

### KEY TO THE SPECIES

1. Plant mass floccose, intricate; trichomes 9–12 μ broad ...... 1. *H. solutum* (p. 433)
1. Plant mass like *Symploca*; trichomes 6–7 μ broad ...... 2. *H. enteromorphoides* (p. 433)

### 1. **Hormothamnion solutum** Bornet et Grunow

*ex* Bornet and Flahault, Revision des Nostocacées hétérocystées, 259, 1888; Forti in De Toni, Sylloge Algarum, 5: 486, 1907; Geitler, Kryptogamenflora, 677, 1892.

Thallus floccose-intricate, mucilaginous, blue-green; filaments 5–6 mm long, 12–15 μ broad, soft, flaccid, free-fasciculate, erect; sheath firm, membranous, hyaline; trichome torulose, 9–12 μ broad; cells discoid, depressed $\frac{1}{3}$–$\frac{1}{4}$ as long as broad; heterocysts nearly quadrate.

Among other algae near Tuticorin (Ferguson ex Born. and Flah., 1888, 260).

### 2. **Hormothamnion enteromorphoides** Grunow ex Born. et Flah.

Grunow, Reise des Novara, Algen, 31, fig. 2, 1867; Born. and Flah., Revision des Nostocacées hétérocystées, 260, 1888; Forti in De Toni, Sylloge Algarum, 5: 486, 1907; Geitler, Kryptogamenflora, 677, fig. 436, 1932.

Pl. 61, Figs. 6, 7, 8

Thallus first mucilaginous, confluent, agglutinated, green or blue-green, when mature caespitose, and simple fasiculate, erect, soft, growing erect from the prostrate base, fastigiate, branched about 2 cm long; branches attenuated at the apices; filaments 7–9 μ broad, sheath mucilaginous, hyaline, thin; trichome 6–7 μ broad; cells barrel-shaped; heterocysts 6–7 μ broad and 7–10 μ long.

On *Spyridia filamentosa* Krusadi island (Iyengar and Desikachary, 1944, 52).

According to Iyengar and Desikachary (*loc. cit.*) the trichomes in the Indian form are 5.3–6.5 μ broad and the heterocysts are 6.5–7.8 (–9.2) μ broad.

## Family SCYTONEMATACEAE Rabenhorst

Fl. Eur. Alg., 2: 246, 1865.

Filaments with a thick, firm sheath; sheath often lamellated; parallel, divergent or funnel-shaped lamellation; false branched, branches single or geminate; trichomes with a single row of cells; heterocysts intercalary generally and two-pored or basal or terminal and one pored situated next to a single false branch; hormogones present; pseudohormogonia present; spores seen in some.

### KEY TO THE GENERA

1. Heterocysts absent .................... 2
1. Heterocysts present .................... 3
    2. Apices of trichomes distinctly broader than the rest of the trichome *Pseudoscytonema* (p. 441)
    2. Apices of trichomes as broad as the rest .......... *Plectonema* (p. 434)
3. Many trichomes in a sheath .................... *Hydrocoryne* (p. 446)
3. Single trichome in a sheath .................... 4
    4. Apex tapering .................... *Scytonematopsis* (p. 447)
    4. Apex not tapering .................... 5
5. Sheath mostly with parallel lamellation .................... 6
5. Sheath with divergent lamellation; lamellae funnel-shaped...... *Petalonema* (p. 506)
    6. False branches rare, mature filaments crescent-shaped *Camptylonemopsis* (p. 442)
    6. False branches common, filaments not crescent shaped.................. 7
7. False branches usually geminate .................... *Scytonema* (p. 450)
7. False branches usually single and often arising next to a terminal heterocyst *Tolypothrix* (p. 493)

## PLECTONEMA Thuret

Essai class Nostochinées, Ann. Sci. nat. Bot., ser. 6, 1: 375, 1875; Gomont Monogr. Oscillariées, 96, 1892.

Trichomes variously bent, with a thin, firm sheath; false branched, branches single or geminate; heterocysts absent; hormogones present; spores not known.

Lectotype: *Plectonema tomasinianum* (Kütz.) Bornet is designated the type by Geitler (1942). Setchell and Gardner (1919, 78) have earlier proposed *Pl. mirabile* (Dillw.) Thuret as the type. Geitler includes *Pl. mirabile* under *Pl. tomasinianum.*

### KEY TO THE SPECIES

1. Filaments perforating.................... 1. *Pl. terebrans* (p. 435)
1. Filaments not perforating, free .................... 2
    2. Filaments broader than 10 μ .................... 3
    2. Filaments narrower .................... 6

3. Trichomes narrow, 7.4–9.2 μ broad ..................... 2. *Pl. indica* (p. 435)
3. Trichomes broader than 10 μ ..................................................... 4
  4. Trichomes broader than 28 μ ..................... 3. *Pl. wollei* (p. 437)
  4. Trichomes narrower ................................................................ 5
5. Trichomes 10–14 μ broad ............................. 4. *Pl. radiosum* (p. 437)
5. Trichomes broader ............................... 5. *Pl. tomasinianum* (p. 438)
  6. Filaments above 4 μ broad ......................................................... 7
  6. Filaments below 4 μ broad ......................................................... 8
7. Filaments about 6 μ broad ............................ 6. *Pl. hansgirgi* (p. 439)
7. Filaments 3–5 (–8) μ broad............................... 7. *Pl. puteale* (p. 439)
  8. Filaments in the mucilage of other algae ...... 8. *Pl. nostocorum* (p. 439)
  8. Filaments free ................................................................................ 9
9. Cells up to 6 times as long as broad .................. 9. *Pl. dangeardii* (p. 440)
9. Cells up to 3 times as long as broad ........................................................ 10
  10. Filaments 1.7–2 μ broad ..................... 10. *Pl. notatum* (p. 440)
  10. Filaments 2–4 μ broad ..................... 11. *Pl. gracillimum* (p. 441)

### 1. **Plectonema terebrans** Bornet ex Gomont

Sur quelques plantes vivant dans le test calcaire des Mollusques, Bull. Soc. bot. Fr., 36: 163, pl. 10, figs. 5–6, 1889; Gomont, Monogr. Oscillariées, 102, 1892; Forti, in De Toni, Sylloge Algarum, 5: 497, 1907; Geitler, Kryptogamenflora, 683, fig. 437a, 1932; Frémy, Cyano. cotes d'Eur., 99, pl. 25, fig. 5, 1933.

Pl. 61, Figs. 4, 5

Filaments long, flexuous, with sparse false branching; false branches single, sheaths very thin, colourless, not coloured blue by chlor-zinc-iodide; trichome blue-green, not constricted at the cross-walls, 0.95–1.5 μ broad; cells 2–6 μ long, with a granule on either side of the cross-walls, end cells rounded.

On shells of Gastropods, Krusudai islands (Iyengar and Desikachary, 1944, 52).

The Krusudai specimens have non-granulated septa.

### 2. **Plectonema indica** Dixit

The Myxophyceae of the Bombay Province I, Proc. Indian Acad. Sci., B, 3: 99, fig. 2E and F, 1936.

Pl. 83, Fig. 2

Thallus fluffy expanded; filaments irregularly curved and densely entangled, 12.8–14.8 μ broad; trichomes blue-green sparingly branched, possessing both single and geminate branches; sheath firm at first thin and hyaline, later thick and stratified, and up to 3.7 μ thick and yellow-brown, unstained with chlor-zinc-iodide; cells 7.4–9.2 μ broad, almost quadratic or cylindrical up to twice as long as broad, slightly constricted at the joints; end cells rounded.

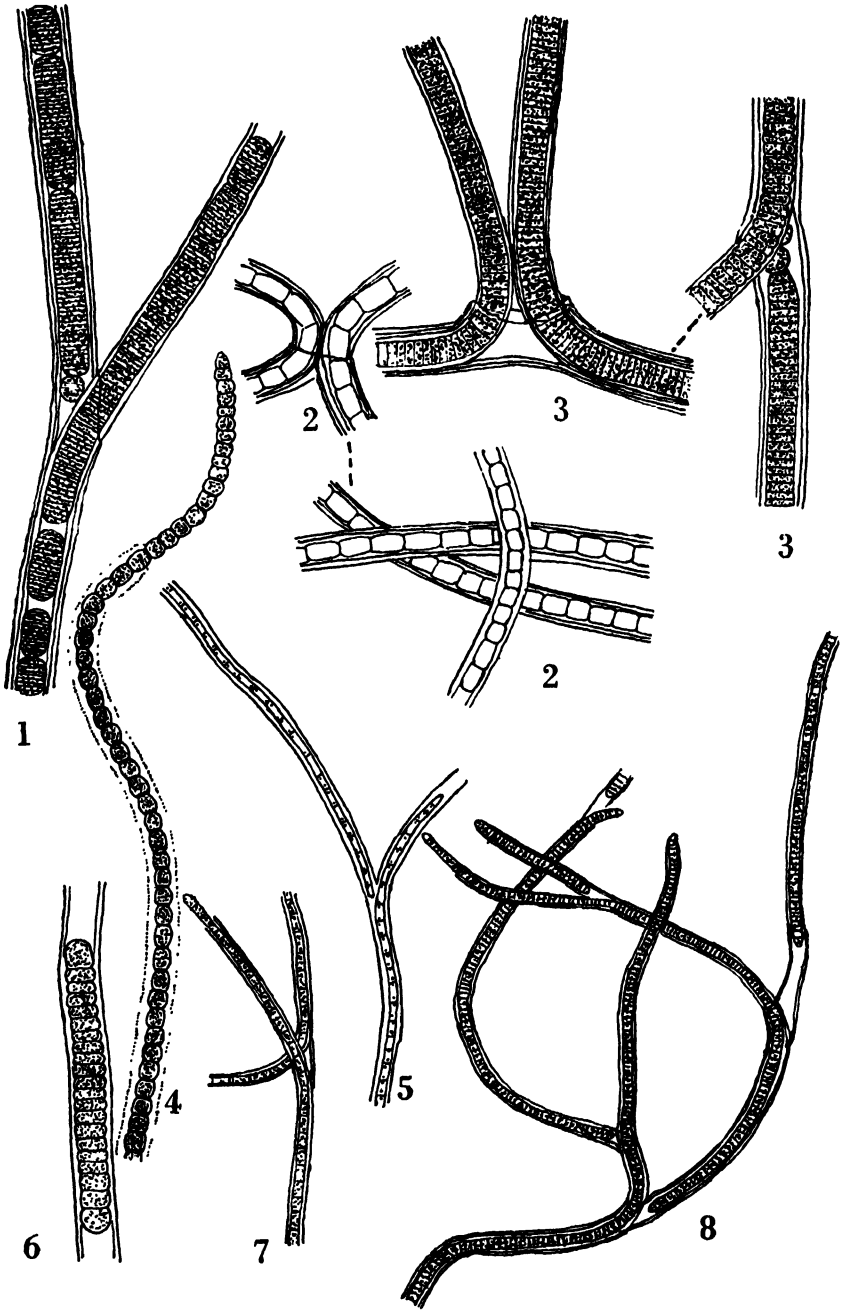

PLATE 83, Figs. 1–8.

1. *Plectonema wollei* Farlow (after Gomont); 2. *P. indica* Dixit (after Dixit); 3. *P. tomasinianum* (Kütz.) Born. (after Bornet); 5. *P. notatum* Schmidle (after Woronichin); 6, 8. *P. radiosum* (Schiederm.) Gom. (after Gomont); 7. *P. nostocorum* Born. (after Gomont); 4. *Phormidium abornema* Skuja (after Skuja).

On walls amidst mosses, Mandapeshwar caves, Borivali, Bombay (Dixit, 1936, 99).

Rao, C. B. (The Myxophyceae of the Madras Presidency I, J. Indian bot. Sec., 17: 86, 1938a), describes a form—Filaments 8.2–13 μ broad, sheath always thin, up to 1.5 μ thick, unstratified, trichome 6.4–8 μ; cells 3.3–16 μ long—occurring on damp walls of a house, Narsapur, Andhra state (Rao, C. B., *loc. cit.*).

### 3. **Plectonema wollei** Farlow ex Gomont

Farlow, remarks on some Algae found in the water supplies of the City of Boston, Bull. Bussey Inst., 77, 1875; Gomont, Monogr. Oscillarieés, 98, pl. 1, fig. 1, 1892; Forti, in De Toni, Sylloge Algarum, 5: 489, 1907; Frémy, Myxo. d'Afr. équat. franc., 166, fig. 144, 1929; Geitler, Kryptogamenflora, 686, fig. 439,1932.

= *Lyngbya pallida* Zeller, Algae collected by Mr. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42 (part 2): 178, 1873.

Pl. 83, Fig. 1

Filaments nearly straight or variously bent, forming a caespitose, expanded, free floating, blackish to yellowish green bundles; false branches sparse, mostly single arising at an oblique angle; sheath colourless, or golden yellow, when old distinctly lamellated, outside uneven, not coloured blue by chlor-zinc-iodide; cells not constricted at the cross-walls, very short, discoid, dull blue-green or yellowish green, 28–47 μ broad, 4–9 μ long, not granulated at cross-walls, end cells rounded.

On submerged rocks, in stagnant and flowing waters.—Wathay-Bwot-Choung, Pegu (Zeller. 1873a, 178; 1873b, 170), Myawadi (West and West, 1907, 241) and Mandalay in Burma (Skuja, 1949, 33), Khandela and Peredeniya in Ceylon (Grun. in Herb. Thuret in Gomont, 1892, 98; Schmidle, 1900b, 161; West and West, 1902, 203); Shembaganur in Madras state (Frémy, 1942, 21).

### 4. **Plectonema radiosum** (Schiederm.) Gomont

Monogr. Oscillariées, 100, pl. 1, fig. 2–2, 1892; Forti, in De Toni, Sylloge Algarum, 5: 492, 1907; Geitler, Kryptogamenflora, 687, fig. 441, 1932.

Pl. 83, Figs. 6, 8

Filaments irregularly curved, more or less radially arranged in a thallus, thallus caespitose, cushion-like, rounded or spherical, about ½ cm long, dull green, or reddish brown; richly false branching, single or geminate; sheath in the lower part of the filament, thick, lamellated, outside uneven, golden yellow, in the upper part thin, hyaline, coloured blue by chlor-zinc-iodide; cells mostly only in the upper parts of trichome distinctly constricted at the cross-walls, 11–22 μ broad, 3–10 μ long, blue-green, cross-walls seldom granulated; end cell rounded.

On damp wooden walls, Rangoon, Burma (Ghose, 1926, 250).

5. **Plectonema tomasinianum** (Kütz.) Born. ex Gomont

Bornet, Les Nostocacées hétérocystées du Systema Algarum de C. Agardh et leur synonymie, Bull. Soc. bot. Fr., 36; 155, 1889; Gomont, Monogr. Oscillariées, 99, 1892; Forti, in De Toni, Sylloge Algarum, 5: 490, 1907; Frémy, Myxo. d'Afr. équat. franc., 173, fig. 146, 1929; Geitler, Kryptogamenflora, 688, fig. 442, 1932.

= *Scytonema natans* Bréb., in Kützing, Species Algarum, 306, 1849.

= *Calothrix brébissonii* Kütz., Species Algarum, 312, 1849.

Pl. 83, Fig. 3

Filaments flexuous, densely entangled forming a caespitose more or less expanded, brownish green or rarely dull blue-green thallus, thallus up to 2 cm high, richly or sparsely false branched, mostly geminate, filaments 11–24 μ broad; sheath up to 3 μ thick, lamellated, at first colourless, later yellowish brown, coloured blue by chlor-zinc-iodide; trichome generally constricted at the cross-walls, 11–22 μ broad; cells $\frac{1}{2}$–$\frac{1}{6}$ as long as broad, 3–9 μ long, seldom longer, blue-green sometimes granulated at the cross-walls; end cells rounded.

Freshwater algae, Central and North India (Turner, 1892, 14).

Var. **gracile** Hansgirg

Sitzb. K. Akad. Wiss. Böhmen, 338, 1891; Forti in De Toni, Sylloge Algarum, 5: 491, 1907; Geitler, Kryptogamenflora, 689, 1932.

Filaments 9–12 μ rarely up to 15 μ broad; false branches single or geminate, commonly almost erect.

In cultures of paddy field soil, Thana, Bombay (Gonzalves and Gangla, 1949, 53).

Var. **vandalurense** var. nov.

Pl. 58, Figs. 1, 2

Filaments forming a leathery stratum, 14.2–25 μ broad; sheath rose-red in colour, thin in young ones and lamellated in older ones, up to 3.5 μ thick, stratification parallel; pseudobranches present, single; trichomes 7.1–17.8 μ broad; constricted at the cross-walls, not attenuated at the apex, apical cell rounded, not conical, not capitate, no calyptra; cells very short up to 3.5 μ long.

On moist soil, Vandalur, near Madras.

This variety is different from the type in the colour of the sheath, branches being single, cross-walls not granulated, and broader filaments and trichomes.

### 6. **Plectonema hansgirgi** Schmidle

Ueber einige von Professor Hansgirg in Östindiengesammelte Süsswasseralgen, Hedwigia, 39: 186, 1900b; Forti, in De Toni, Sylloge Algarum, 5: 489, 1907; Geitler, Kryptogamenflora, 691, 1932.

Thallus flat, expanded, up to 20 cm in diam.; filaments densely intricate, 6 μ broad, very sparsely false branched; sheath thin, colourless, very much conspicuous, not coloured blue by chlor-zinc-iodide; false branches single, diverging at an acute angle; cells somewhat longer than broad; hormogones small, few-celled, straight; end cell broadly rounded, often a little less broad.

On tree trunks near Matheran in Bombay state (Schmidle, 1900b, 186) and in cultures of paddy field soil from Khandala near Bombay (Gonzalves and Gangla, 1949, 54).

### 7. **Plectonema puteale** (Kirchner) Hansgirg.

Über den Polymorphismus den algen, Bot. Centralbl., 22: 18, pl. 2, figs. 15 and 16, 1885; Prodromus der Algenflora von Böhmens, 2: 40, 1892; Forti, in De Toni, Sylloge Algarum, 5: 493, 1907; Geitler, Kryptogamenflora, 691, 1932.

Filaments in small floccose, pale blue or yellow-green, seldom nearly colourless masses, 3–5 seldom up to 8 μ broad, false branches mostly short; cells 2–4 ( –4.5) μ broad, slightly constricted at the cross-walls, 1–4 times longer than broad, dull blue-green, or nearly colourless; sheath thin, mostly colourless, 3–8 μ thick, seldom yellow to brown, thick and opaque.

Rangoon (Skuja, 1949, 33).

Gomont (1892, p. 103) rejects this species (Sitzb. k. böhm. Ges. Wiss., 143, 1889) also as a bacteria. Elenkin (1949, p. 1782) refers to it as *Plectonema puteale* (Kirchn.), Hansg. (Prodromus Algenflora von Böhmens, 2: 40, 1892) *sed non* Hangirg, 1885.

### 8. **Plectonema nostocorum** Bornet ex Gomont

Bornet, in Bornet and Thuret, Notes algologiques, 2: 137, 1887; Gomont, Monogr. Oscillariées, 102, pl. 1, fig. 11, 1892; Forti, in De Toni, Sylloge Algarum, 5: 495, 1907; Frémy, Myxo. d.Afr. équat. franc., 170, fig. 149, 1929;

Geitler Kryptogamenflora, 692, fig. 445, 1932; Frémy, Cyano, cotes d'Eur., 97, pl. 25, fig. 2, 1933.

Pl. 83, Fig. 7

Filaments nearly straight or flexuous; false branches sparse, single or geminate; sheath thin, colourless, not coloured by chlor-zinc-iodide; cells cylindrical, sometimes constricted at the cross-walls, septa not granulated, (0.7–) 1–1.5 μ broad and 2–2.5 (–3) μ long, pale blue-green; end cell rounded.

In the environs of Shembaganur in Madras state (Frémy, 1942, 21); in cultures of paddy field soil from Khandala near Bombay (Gonzalves and Gangla, 1949, 54).

f. **discolor** Cedercreutz

Mem. Soc. Fauna Fl. Fennica, 5: 155, 1929; Geitler, Kryptogamenflora, 693, 1932.

Sheath brownish; rest as in type.

In the mucilage of *Nostochopsis lobatus* in a lake, Rangoon, Burma (Skuja, 1949, 33).

9. **Plectonema dangeardii** Frémy

Myxo. d'Afr. équat. franc., 175, fig. 148, 1929; Geitler, Kryptogamenflora, 694, fig. 446, 1932.

Pl. 56, Fig. 5

Filaments single or a few together, nearly straight, 2.5 μ broad, repeatedly false-branched, false branches mostly geminate seldom single, growing erect; sheath colourless, firm, cylindrical, not coloured blue by chlor-zinc-iodide; trichome pale blue-green, not constricted at the cross-walls, 1.5 μ broad; cells 2–6 times longer than broad, 3–9 μ long, cross-walls not granulated, end cells rounded, without calyptra.

In stagnant waters, Perukuda in Travancore (Parukutty, 1940, 118).

According to Parukutty the filaments are 1.6–2 μ broad and the cells are 2.5–3.3 μ long rarely up to 9 μ long.

10. **Plectonema notatum** Schmidle

in Simmer's IV, Ber. über d. Kryptogamenflora v. Kreuzecker, Allg. bot. Zeitschr., n. $^3/_4$; 84, figs. 8 and 9, 1901; Geitler, Kryptogamenflora, 693, 1932.

Pl. 83, Fig. 5

Filaments variously bent, not forming any distinct thallus, 1.7–2 μ broad; false branching sparse, single or geminate; sheath thin, colourless; cells cylindrical, 2–3 times as long as broad, with two granules at the cross-walls, not constricted, pale blue-green, end cell rounded.

Type not recorded.

### Var. **africanum** Fritsch, F. E.

Trans. roy. Soc. S. Afr., 18: 90, fig. 31, 1929.

Filaments densely entangled, 4–5 μ broad, forming a thallus; false branching sparse, single or seldom two; sheath more or less slimy; end cell truncated, rounded.

Amidst *Scytonema pseudopunctatum*, epiphytic or *Zizyphus jujuba*, Rangoon, Burma (Skuja, 1940, 33).

The trichomes in the Rangoon alga are about 2.5 μ broad and are slightly constricted at the cross-walls.

### 11. **Plectonema gracillimum** (Zopf) Hansgirg

Ueber den Polymorphismus der Algen, Bot. Centralbl., 22: 48, pl. 1, 1885; Prodromus der Algenflora von Böhmens, 2: 41, 1892; Forti in De Toni, Sylloge Algarum, 5: 493, 1907; Geitler, Kryptogamenflora, 693, 1932.

Thallus thin membranous, often later expanded, pale blue, yellowish or grey-green, mostly slimy; filaments 2–4 μ broad; false branches single or geminate; cells 1–3 times longer than broad, dull blue-green, nearly colourless; sheath thin, mostly colourless.

In hot springs (49°C), Vajreshwari near Bombay (Gonzalves, 1947, 25); in cultures of paddyfield soil from Thana near Bombay (Gonzalves and Gangla, 1949, 53/54).

Gomont (1892, p. 103) excludes this species? (*Pl. gracillimum* Hansg., Durchforschung der saprofilischen Bacterien Böhmens. sitzb. K. böhm. Ges. Wiss., 143, 1889) as bacteria. This species has, however, been recognized by most workers.

## PSEUDOSCYTONEMA Elenkin

Monogr. Alg. Cyan., pars. spec., fasc. 2: 1805, 1949.

Filaments and trichome false branched; apices of trichome symmetrically dilated as in *Scytonema,* growth apical; heterocysts absent.

Monotypic: *P. malayense* (Biswas) Elenkin ( = *Plectonema malayense* Biswas).

### **Pseudoscytonema malayense** (Biswas) Elenkin

Monogr. Alg. Cyan., pars. spec., fasc. 2, 1805, fig. 548, 1949.

= *Plectonema malayense* Biswas, J. Fed. Malay States Mus., 14: 411, pl. 10, fig. 24, 1929.

Pl. 95, Fig. 4

Filaments entangled, flexuous, 16–20 μ broad, gradually wider towards the apices; false-branches in pairs; sheaths colourless, not lamellose, 5–6 μ in thickness; trichomes gradually attenuated towards the central portions, where the cells are thinner and more elongated, but broadened towards the apices, with wider but shorter constricted cells; cells 6–8 μ in diam. near the middle, 12–16 μ in width at the base, intermediate cells 12–20 μ length and 6–8 μ in width, end-cells broadly obtusely rounded, 4–6 μ in length, 12–16 μ in width; transverse walls not granulated; cell contents closely granular, blue-green.

In a dirty pond near waterworks, Ampang, Malaya (Biswas, *loc. cit.*).

## CAMPTYLONEMOPSIS Desikachary

On *Camptylonema indicum* Schmidle and *Camptylonemopsis* gen. nov., Proc. Indian Acad. Sci., B, 18: 46, 1948.

Filaments bent more or less like a crescent, with a median heterocyst and with two ends of filaments growing upwards, simple or rarely false-branched; true branches absent; trichome forming a single row of cells; heterocysts intercalary or at the base of a false-branch; hormogones present; homocysts not known; spores formed in series.

Type species: *C. lahorensis* (Ghose) Desikachary ( = *Camptylonema lahorense* Ghose).

Geitler (1932) states that in case true branching should be found in *Camptylonema indicum* then Ghose's alga, *Camptylonema lahorense* (which shows only false branching, but no true branching), should be placed in a new genus. Desikachary (1948) in a new collection of *Camptylonema* Schmidle found the presence of true branches and consequently Ghose's alga was placed under *Camptylonemopsis*. This genus was originally included under Microchaetaceae by him. Restricting the Microchaetaceae to forms with polarity i.e., having a basal heterocysts and transference of *Aulosira* to the Nostocaceae necessitates a change in the position of *Camptylonemopsis*. The genus resembles generally the early stages of the hormogone germination seen in many Scytonemataceae and hence may be included under the same family though false branching is either rare or absent. The stages in the germination of the hormogones suggest

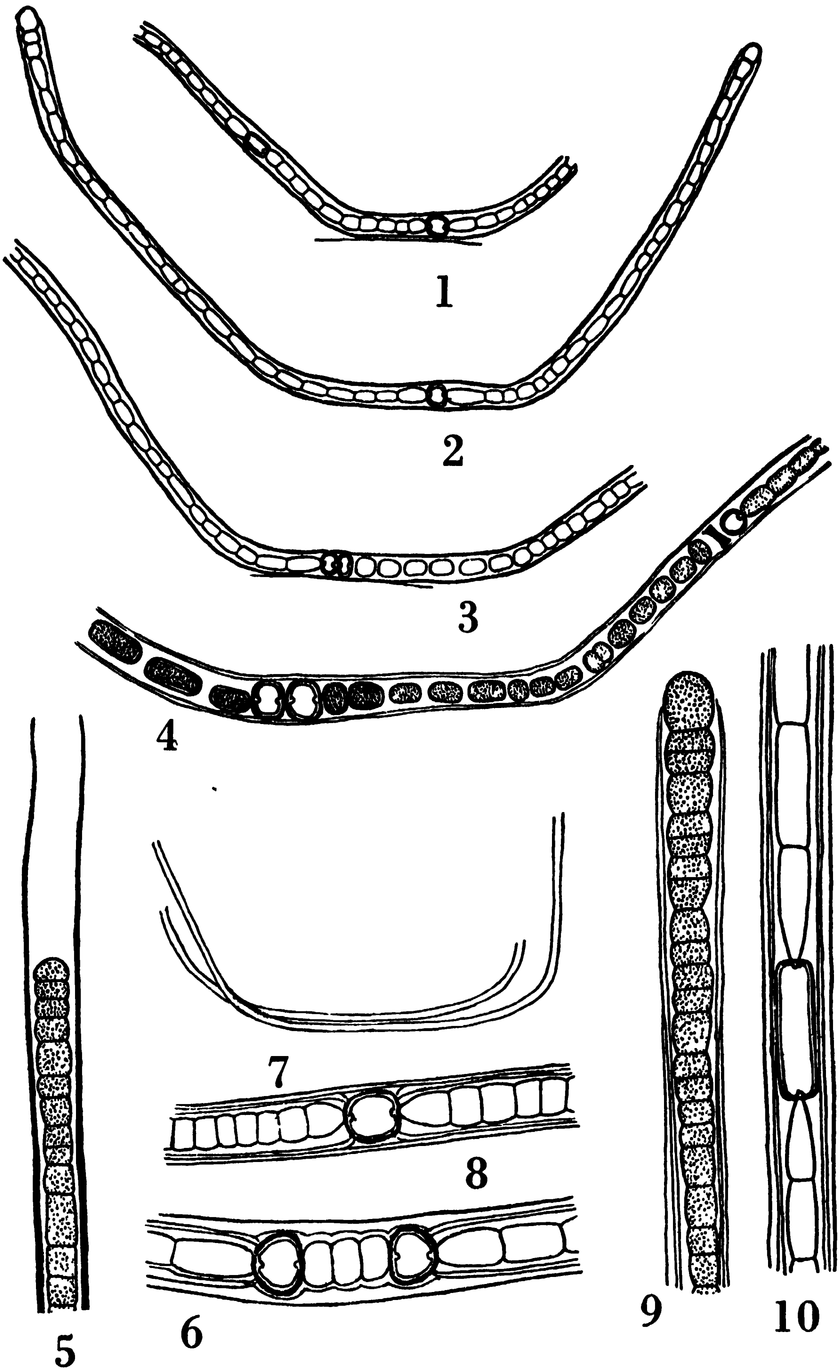

PLATE 84, Figs. 1–10.

1–5. *Camptylonemopsis minor* Desikachary (after Desikachary); 6–10. *C. pulneyensis* Desikachary (after Desikachary).

that the Microchaetaceae might have been derived from ancestors similar to the present genus (*see* Desikachary, 1948, p. 46).

## KEY TO THE SPECIES

1. Aquatic, filaments 7.9–13.1 μ broad ...................... 1. *C. pulneyensis* (p. 444)
1. Aquatic, filaments 3.9–7.9 μ broad ........................ 2. *C. minor* (p. 444)
    2. Semi-aquatic or on wet soil, epiphytic, filament 5.2–6.6 μ broad
    3. *C. iyengarii* (p. 446)
    2. Semi-aquatic or on wet soil, not epiphytic, trichome 6–9 μ broad
    4. *C. lahorensis* (p. 446)

### 1. **Camptylonemopsis pulneyensis** Desikachary

On *Camptylonema indicum* Schmidle etc., Proc. Indian Acad. Sci., B, 18: 47, figs. 16–24, 1948.

Pl. 84, Figs. 6–10

Plant mass small, light blue-green in colour; filaments bent into a crescent-shape, 7.9–13.1 μ broad; sheath firm, thick, lamellated, and hyaline; unbranched or rarely with false branches; true branches absent; trichome in the middle region 5.24–9.3 μ broad, narrower in older portions (rarely even 3.9 μ broad), and in the side portions 3.9–6.6 μ broad; apices slightly broader than the portion below and rounded; trichome generally constricted at the cross-walls; cells shorter or longer than broad, 5.2–20 μ long; heterocysts intercalary, median heterocysts spherical and 7.9–10.5 μ broad; in the other portions cylindrical, 5.2–7.9 μ broad and 7.9–19.6 μ long; hormogones present.

Among other algae in a pool near lake, Kodaikanal.

### 2. **Camptylonemopsis minor** Desikachary

On *Camptylonema indicum* Schmidle etc., Proc. Indian Acad. Sci., B., 18: 47, figs. 25–29, 1948.

Pl. 84, Figs. 1–5

Filaments short, flexuous, 3.9–7.9 μ broad; sheath thin, hyaline, firm without any distinct lamellation; branching not seen; trichome with one or two median heterocysts, constricted at the cross-walls, 2.6–5.2 μ broad; apices of trichome slightly broader, rounded; cells spherical or barrel-shaped, 3.9–9.2 μ long; heterocysts usually intercalary nearly spherical when median, 3.9–6.6 μ broad, in other portions cylindrical and up to twice as long as broad; spores formed in series close to the heterocysts, 3.9–6.6 μ broad and 5.2–10.5 μ long.

Epiphytic on *Camptylonemopsis pulneyensis* in a pool near lake, Kodaikanal.

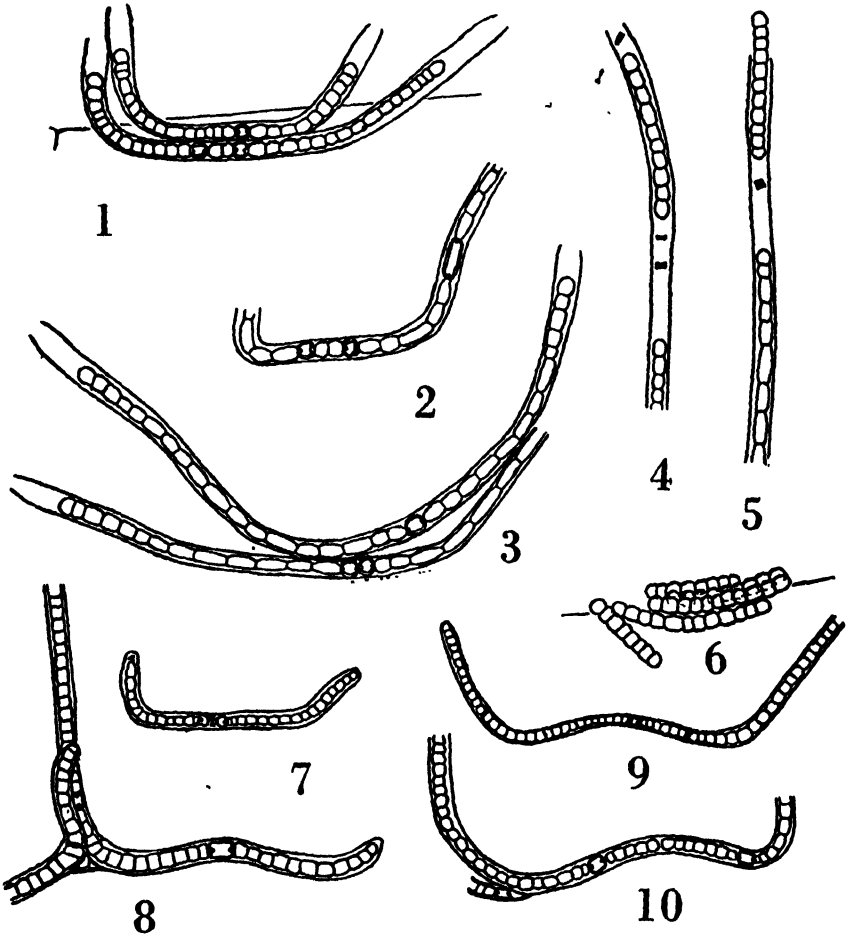

PLATE 85, Figs. 1–10.

1–6. *Camptylonemopsis iyengarii* Desikachary (after Desikachary); 7–10. *C. lahorensis* (Ghose) Desikachary (after Ghose).

### 3. **Camptylonemopsis iyengarii** Desikachary

On *Camptylonema indicum* Schmidle etc., Proc. Indian Acad. Sci., B, 18: 47, figs. 30–40, 1948.

Pl. 85, Figs. 1–6

Filaments epiphytic on *Sirogonium* filaments, crescent-shaped with a flat attached middle region and lateral erect portions, 5.2–6.6 μ broad; sheath thin, hyaline, homogeneous; false-branching not seen; trichome torulose (2.6–) 3.9–5.2 μ broad; apex of the trichome slightly broader, rounded; cells spherical, barrel-shaped or sometimes cylindrical, 3.9–5.2 μ broad in the middle region and near the apex, 2.6–3.9 μ broad and 5.2–10.5 μ long in the rest of the trichome; heterocysts intercalary, median heterocysts nearly spherical (3.9–) 5.2–6.6 μ broad, in other portions 3.9–5.2 μ broad and up to 15.7 μ long; hormogones present; spores not seen.

Epiphytic on filaments of *Sirogonium* sp., on moist soil, Vandalur.

### 4. **Camptylonemopsis lahorensis** (Ghose) Desikachary

On *Camptylonema indicum* Schmidle etc., Proc. Indian Acad. Sci., B, 18: 49, figs. 41–45, 1948.

Pl. 85, Figs. 7–10

= *Camptylonema lahorense* Ghose, New Phytol., 19: 35–39, figs. 1–6, 1920.

Thallus woolly, bright bluish green, or bluish brown, terrestrial, partly embedded in mud and partly above it; sheath inconspicuous, thin and hyaline in the embedded region and firm, thick and lamellose, lightly adhering and brown in the exposed portion; filaments curved in a more or less semicircular manner, up to 1¼ mm in length; the trichome bluish green, 6–9 μ broad, slightly constricted at the joints; rarely pseudo-branched, pseudo-branches given off singly or in pairs; cells isodiametric or a little longer than broad, transverse walls scarcely conspicuous in the older filaments; heterocysts median or found at intervals throughout the length of the filament, rectangular or ellipsoidal, 12–21 μ long and 7–9 μ wide; spores 7–11 μ long and 5–7 μ wide, formed in a chain within the sheath, episporium brown and smooth; cell-contents coarsely granular.

On damp lawns and waste grounds, Lahore, Pakistan.

## **HYDROCORYNE** Schwabe

in Sprengel, Systema vegetabilium, 4 (1) : 314, 1827; Bornet and Flahault, Revision des Nostocacées hétérocystées, 128, 1887.

Trichome irregularly branched, mostly many in a sheath; false branches single, long, lying close to the main filament; filaments and branches more or less parallel; heterocysts intercalary; spores present.

Monotypic: *Hydrocoryne spongiosa* Schwabe.

Drouet (1951) transferred this genus from the Scytonemataceae to the Nostocaceae.

### **Hydrocoryne spongiosa** Schwabe ex Born. et Flah.

in Sprengel, Systema vegetabilium, 4 (1): 373, 1827; Bornet and Flahault, Revision des Nostocacées hétérocystées, 128, 1887; Forti in De Toni Sylloge Algarum, 5: 557, 1907; Geitler, Kryptogamenflora, 798, fig. 511, 1932; Frémy, Cyano. cotes d'Eur., 164, pl. 51, fig. 3, 1933.

= *Calothrix tenuissima* A. Br., in Rabenh., Fl. Eur. Alg., 2; 271, 1865.

Thallus expanded, gelatinous, membranous, spongy, torn, dirty green; filaments entangled 4–6.5 (–7) μ broad; sheath thin, colourless; false branches sparse, as broad as the main filament; parallel with the main filament and fusing at the base, sometimes in bundles up to 30 μ broad; cells 3–4 (–5) μ broad, long ellipsoidal or short barrel-shaped, 4 μ broad, sometimes up to 5 μ broad, 1–2 times as long as broad; heterocysts intercalary, nearly oblong about 4 μ broad; spores single, oblong or ellipsoidal, 5–7 μ broad, up to twice as long as broad.

Freshwater algae, N. India (Turner, 1892, 14).

Nielson (Quart. J. Florida Acad., Sci., 16 (1): 1–3, 1953) has redescribed the species based on a study of the type material and also a number of other collections.

## SCYTONEMATOPSIS Kisselewa

Eine neue Blaualga *Scytonematopsis woronichinii* mihi., J. Soc. Bot. Russ., 15: 174, 1930.

Filaments branched, branching false, gradually attenuated towards the tip, growth by intercalary division; sheath present; heterocysts and spores present.

Type species: *Scytonematopsis woronichinii* Kissl.

### KEY TO THE SPECIES

1. Spores 5–7 μ broad, and 3–7 μ long ........................ 1. *S. kashyapi* (p. 448)
1. Spores 7–10.5 μ broad, and 10–19 μ long............... 2. *S. woronichinii* (p. 448)

### 1. **Scytonematopsis kashyapi** (Bharadwaja) Geitler

Arch. Hydrobiol. (u. Planktonk.), Suppl. 14: 445, 1935.

= *Spalaeopogon kashyapi* Bharadwaja, *Spelaeovogon Kashyapi* n. sp., a new member of the Scytonemataceae, Ann. Bot., Lond., 42: 69–74, figs. 1–2, 1928.

Pl. 86

Thallus made of a small slimy wooly tuft of a dirty bluish green colour: sheath conspicuous, hyaline, thick and firm, often lamellose; filaments straight or slightly curved, 5–6 mm in length, bulged out opposite the heterocysts; trichomes 5–6 μ in diam., slightly constricted at the joints, simple but generally with false branches, false branches given off singly in connection with biboncave discs of intercellular substance; cells 2–4 times as long as broad, transverse walls distinct; heterocysts few at considerable intervals, throughout the whole length of the filament, ellipsoidal or void, 11–20 μ long and 5–10 μ broad; hormogones long, enclosed by the parent sheath; spores in chains, rarely interrupted by heterocysts, about 5–7 μ broad and 3–7 μ long, with a thick smooth epispore.

On *Ceratophyllum* in stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

### 2. **Scytonematopsis woronichinii** Kiss.

J. Soc. Bot., 15: 174, pl. 1, figs. 1, 2, 1930.

Filaments 5–8 μ broad, interlacing or sometimes in bundles; the branching invariably false, single or geminate; trichome in the main filament 5–6.5 μ broad, cells mostly quadratic or may be shorter or longer than their breadth and distinctly constricted at the transverse walls, when old almost torulose; cells of the branches 4–6 μ broad, as long as broad or up to 12 μ long and slightly constricted at the transverse walls, apical cell somewhat conical with an obtuse tip and homogeneous contents; trichomes very slightly and gradually attenuated at the free ends; sheath firm, uniformly thick, unstriated and hyaline, in old filaments yellowish or yellowish brown, not coloured blue or violet with chlor-zinc-iodide; hormogonia formed profusely of varying length, few to many celled; akinetes formed in old cultures, at the terminal ends of the filaments which almost always get displaced during growth as a lateral branch, in chains interspersed with biconcave discs or may be contiguous, oval, oblong or ellipsoidal, 7–10.5 μ broad and 10–19 μ long with a smooth and firm wall up to 2 μ thick.

In a culture of soil from an Indian rice-field.

A. B. Gupta (Hydrobiologia, 7: 373, 1954) has described this species from India. He describes also spore formation and their germination. According to him, *Scytonematopsis* is not very distinctive and suggests the transference of the different species to other genera, *S. calothrchoides* to *Calothrix*, *S. incerta* to *Tolypothrix* and *S. kashyapi* and *S. woronichinii* to *Scytonema*.

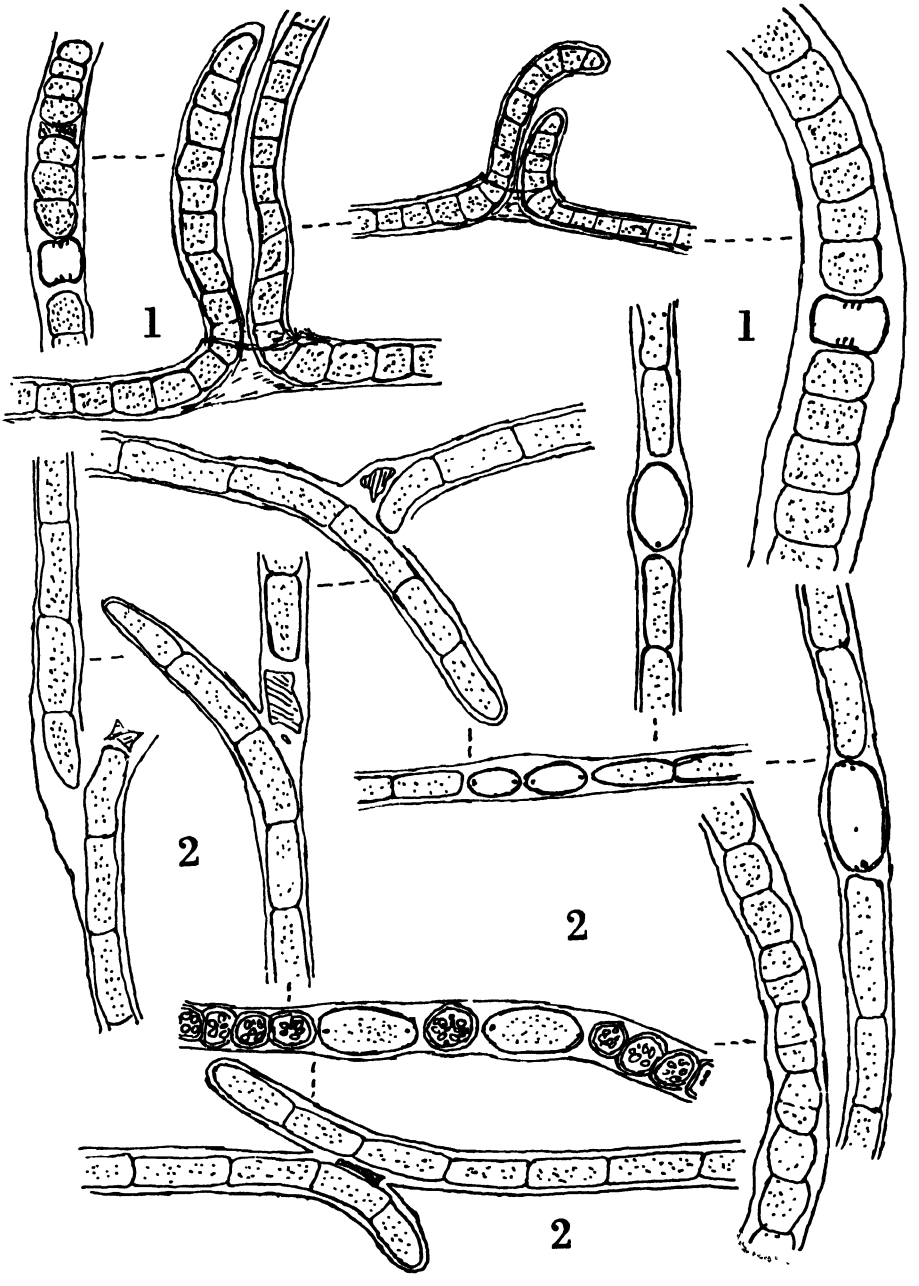

PLATE 86, Figs. 1–2.

1. *Scytonema malaviyaensis* Bharadw.; 2. *Scytonematopsis kashyapii* (Bharadw.) Geitler (all after Bharadwaja).

## SCYTONEMA Ag.

Systema Algarum, 26, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 85, 1887.

Filaments false branched, false branches single or geminate, formed laterally generally in between heterocysts; trichomes single in each sheath, straight; hormogones terminal, solitary; pseudo-hormogonia present; spores known only in a few species, spherical or ovate, exospore thin and smooth.

Type species: *S. hofmanni* Ag.

The mode of development of the false branching in the Scytonemataceae has been studied by a number of workers (Bornet and Flahault, 1885, 1886a; Frémy, 1929; Goncalves Guerero 1933, Geitler, 1932, 1936; Bharadwaja, 1933b; *see* also, page 37). The degree of variation in the nature of branching seen in the different genera has naturally set a doubt on the separation of the genera, *Scytonema, Tolypothrix, Hassallia* and *Petalonema.* For a long time *Scytonema* and *Tolypothrix* have been separated of predominance of geminate or single branches. Some go to the extent of suggesting that there is no need to keep these genera distinct. Bharadwaja based on a study of a number of species of *Scytonema* and *Tolypothrix* suggested restricting the latter genus to forms with false branches arising or situated next to single pored heterocysts. Consequently he suggested transfer of 10 species from *Tolypothrix* to *Scytonema.*

Similarly the separation of *Petalonema* from *Scytonema* is disputed by many. Bornet and Flahault (Revision des Nostocacées hétérocystées, 1887) included it in *Scytonema* (*see* also Bharadwaja, 1933). The separation is based mainly on the formation and structure of the sheath and appears to be convenient. Only a few distinct species of *Petalonema* are retained and the rest are left behind in *Scytonema.*

*Hassallia* Berk., has been included under *Tolypothrix* (*see* Bornet and Flahault, 1887; Geitler, 1932). Geitler, however, in 1942 resusciated this genus. *Hassallia* included terrestrial forms with only single false branches arising besides single pored heterocysts, and the filaments are extremely fragile.

If the suggestion of Bharadwaja restricting the genus *Tolypothrix* is accepted, then probably the former character will be significant in *Tolypothrix* itself and leaves only the latter character which is of doubtful value in separating *Hassallia* from *Tolypothrix.*

### KEY TO THE SPECIES

| | |
|---|---|
| 1. Sheath homogeneous, or with parallel lamellation, generally thin, *Euscytonema* | 2 |
| 1. Sheath lamellated, mostly with divergent lamellation, terrestrial, *Myochrotes* | 30 |
| 2. Aquatic | 3 |
| 2. Terrestrial | 11 |
| 3. Cells quadratic or shorter broad | 4 |
| 3. Cells quadrate or longer than broad | 6 |
| 4. Filaments about 30 μ broad | 1. *S. rivulare* (p. 452) |
| 4. Filaments narrower | 5 |

5. Filaments 25–27 μ broad.......... 2. *S. chiastum* (p. 453
5. Filaments 16–36 μ broad.......... 3. *S. cincinnatum* (p. 453)
 6. Trichomes up to 10 μ broad .......... 8
 6. Trichomes broader than 10 μ .......... 7
7. Filaments 14–15.7 μ broad, trichomes 9.4–11.7 μ broad .......... 4. *S. simplex* (p. 455)
7. Filaments 18–24 μ broad, trichomes 12–18 μ broad .......... 5. *S. coactile* (p. 455)
 8. Trichomes prominently dilated, 3 μ broad, apices 10 μ broad, filaments 14 μ broad.......... 6. *S. leptobasis* (p. 457)
 8. Trichomes not prominently dilated, filaments broader .......... 9
9. Filaments 10–12 μ broad, trichomes 5–8 μ broad .......... 7. *S. bohneri* (p. 457)
9. Filaments broader .......... 10
 10. Filaments 15–20 μ broad, trichomes 7–8 μ broad.......... 8. *S. fritschii* (p. 458)
 10. Filaments 16 μ broad, trichomes 4–8 μ broad .......... 9. *S. caldarium* (p. 458)
11. Cells shorter than broad .......... 12
11. Cells longer than broad .......... 21
 12. Trichomes constricted.......... 13
 12. Trichomes unconstricted .......... 15
13. Filaments 16–30 μ broad.......... 10. *S. stuposum* (p. 459)
13. Filaments narrower .......... 14
 14. Trichomes 9–12 μ broad .......... 11. *S. schmidtii* (p. 459)
 14. Trichomes 10–15 μ broad .......... 12. *S. millei* (p. 460)
15. Filaments about 20 μ broad .......... 17
15. Filaments narrower .......... 16
 16. Filaments 14–16 μ broad .......... 13. *S. burmanicum* (p. 460)
 16. Filaments 12–15 μ broad .......... 14. *S. javanicum* (p. 461)
17. Filaments 16–20 μ broad.......... 15. *S. saleyeriense* (p. 461)
17. Filaments 18.9–22 μ broad .......... 16. *S. pascheri* (p. 463)
17. Filaments 10–18 μ broad.......... 18
 18. Cells very short .......... 19
 18. Cells as long as broad or somewhat shorter.......... 20
19. Trichomes 10–16 μ broad, cells ¼–⅛ as long as broad .......... 17. *S. hansgirgi* (p. 463)
19. Trichomes 9.4–14.7 μ, cells ½–⅓ as long as broad, sheath thick 18. *S. iyengarii* (p. 465)
 20. Sheath thick, apices dilated and distinctly broader. 19. *S. dilatatum* (p. 465)
 20. Sheath not so thick, apices not distinctly broader . 20. *S. ocellatum* (p. 467)
21. Filaments above 15 μ diam. .......... 22
21. Filaments below 15 μ diam. .......... 24
 22. Filaments (18–) 19–24 (–26) μ broad .......... 21. *S. amplum* (p. 469)
 22. Filaments narrower .......... 23
23. Filaments 15–25 μ broad, trichomes 13–18 μ broad .. 22. *S. pseudopunctatum* (p. 469)
23. Filaments 15–21 μ broad, trichomes 10–16 μ broad .......... 23. *S. guyanense* (p. 469)
23. Filaments 15–18.9 (–23.1) μ broad, trichomes 8.4–9.5 (–10.5) μ broad 24. *S. pseudoguyanense* (p. 472)
 24. With calcium incrustation .......... 25. *S. julianum* (p. 472)
 24. Without calcium incrustation .......... 25
25. Sheath firm .......... 26
25. Sheath gelatinous, trichomes 5–7 μ broad .......... 26. *S. varium* (p. 474)
 26. Trichomes up to 5 μ broad .......... 27
 26. Trichomes broader .......... 28
27. Filaments 9 μ broad, trichomes 5 μ broad .......... 27. *S. frémyii* (p. 474)

27. Filaments 5–6 μ broad, trichomes 3–4 μ broad .......... 28. *S. schmidlei* (p. 474)
27. Filaments 12–17 μ broad, trichomes 2–4 μ broad .......... 29. *S. subtile* (p. 475)
28. Cells not very long .......................................... 29
28. Cells very long, filaments 9.5–13 μ broad ..... 30. *S. multiramosum* (p. 475)
29. Filaments 7–12 (–15) μ broad, trichomes 5–10 μ broad, sheath not lamellate 31. *S. hofmanni* (p. 476)
29. Filaments 8–12.6 (–13.6) μ broad, trichomes 5.2–7.3 μ broad, sheath lamellate 32. *S. pseudohofmanni* (p. 478)
30. Sheath with slightly divergent lamellation ........................ 31
30. Sheath with distinctly divergent lamellation often with funnel shaped portions 35
31. Filaments 15–21 μ broad ........................................ 33
31. Filaments narrower .............................................. 32
32. Filaments 10–15 μ broad, trichomes 8–12 μ broad 33. *S. tolypothricoides* (p. 479)
32. Filaments 10.5–12.6 μ broad, trichomes 4.2–6.3 (–10.5) μ broad 34. *S. geitleri* (p. 481)
33. Trichomes 3.5 6 μ broad ............................ 35. *S. bewsii* (p. 481)
33. Trichomes broader ................................................ 34
34. Trichomes 6.5–8.5 μ broad ................ 36. *S. malaviyaensis* (p. 483)
34. Trichomes 6–12 μ broad ........................ 37. *S. mirabile* (p. 483)
35. Branches free .................................................... 36
35. Branches united at the base ........................ 38. *S. crustaceum* (p. 485)
36. Filaments 18–36 μ broad...................... 39. *S. myochrus* (p. 487)
36. Filaments 27–48 μ broad...................... 40. *S. crassum* (p. 489)

### 1. **Scytonema rivulare** Borzi ex Born. et Flah.

Morfologia e Biologia delle alghe Ficocromacee. N. Giorn. bot. ital., 11: 373, 1879; Bornet and Flahault, Revision des Nostocacées hétérocystées, 91, 1887; Forti in De Toni, Sylloge Algarum, 5: 501, 1907; Frémy, Myxo. d'Afr. équat. franc., 300, 1929; Geitler, Kryptogamenflora, 751, 1932.

Pl. 100, Fig. 2

Thallus broadly expanded, tomentose, blackish brown to reddish; filaments sparsely false-branched, variously bent or curved, about 30 μ broad; sheath firm close, homogeneous, smooth, up to about 5 μ thick; cells quadrate or shorter than broad; heterocysts as broad as the vegetative cells, orange or yellowish; spores globose, blackish, exospore firm and smooth.

On aquatic mosses, in the environs of Shembaganur, Madras state (Frémy, 1942, 33).

Borzi (*loc. cit.*) described the germination of the spores in this species. They germinated in May. The contents of the spore first divided into two. The germling emerges out of the epispore and immediately secretes a mucilaginous sheath. The germling after attaining some length multiplies by hormogone formation.

### 2. **Scytonema chiastum** Geitler

In Pascher's Süsswasserflora, 12: 269, figs. 318 and 319, 1925; Kryptogamenflora, 750, fig. 478, 1932.

Pl. 90, Fig. 1

Thallus floccose-flushy, blue-green, olivaceous or brown; filaments up to 1½ cm long, nearly straight, mostly 25–27 μ broad, when old up to 31 μ and when young up to 20–25 μ broad; richly false-branched, seldom single, mostly geminate, branches united at the base or running to some distance with the main filament, false branches long, narrower than the main filament, mostly 20 μ broad; older filaments with calcium incrustation; sheath thick, firm, with parallel lamellation, when young totally colourless later brownish; cells shorter than broad, mostly ⅓ as long as broad, seldom nearly quadrate, blue-green to olive green, mostly barrel-shaped, in the older portions of the trichome cylindrical, and a little constricted at the cross-walls; heterocysts single to many, round quadrate or nearly spherical.

Type not recorded.

#### f. **minor** Parukutty

The Myxophyceae of the Travancore state, India, Proc. Indian Acad. Sci., B, 11: 119, 1940.

Filaments 18–26.4 μ broad; trichomes 12–15 μ broad; cells 3.3–6.6 μ long; heterocysts 9–15 μ broad and 15–17 μ long.

In a rice field, Perukada, Travancore (Parukutty, *loc. cit.*).

### 3. **Scytonema cincinnatum** Thuret ex Born. et Flah.

Thuret, Essai de classification des Nostochinées, Ann. Sci. nat., 6 ser., Bot., 1: 380, 1875; Bornet and Flahault, Revision des Mostocacées hétérocystées, 89, 1887.

= *Lyngbya cincinnata* Kütz., Phyc. gene., 226, 1843.

= *Scytonema crispum* (Ag.) Bornet, Les Nostoc. hétéroc. dul Syst. Alg. de C. Agardh Bull. bot. Soc. Fr., 36: 156, 1889; Forti in De Toni, Sylloge Algarum, 5: 498, 1907; Frémy, Myxo. d'Afr. équat. franc., 298, fig. 257, 1929; Geitler, Kryptogamenflora, 748, fig. 477, 1932.

Pl. 93, Fig. 1

Stratum caespitose, intricate, woolly, olivaceous, to brownish green; filaments 16–36 μ mostly 18–30 μ broad, 3 cm or more long, crisp; false branches mostly geminate, sometimes very sparsely false-branched; sheath firm, membranaceous, hyaline, rarely brownish; trichome 14–30 μ broad, blue-green or olive or brownish violet, distinctly or very little constricted at

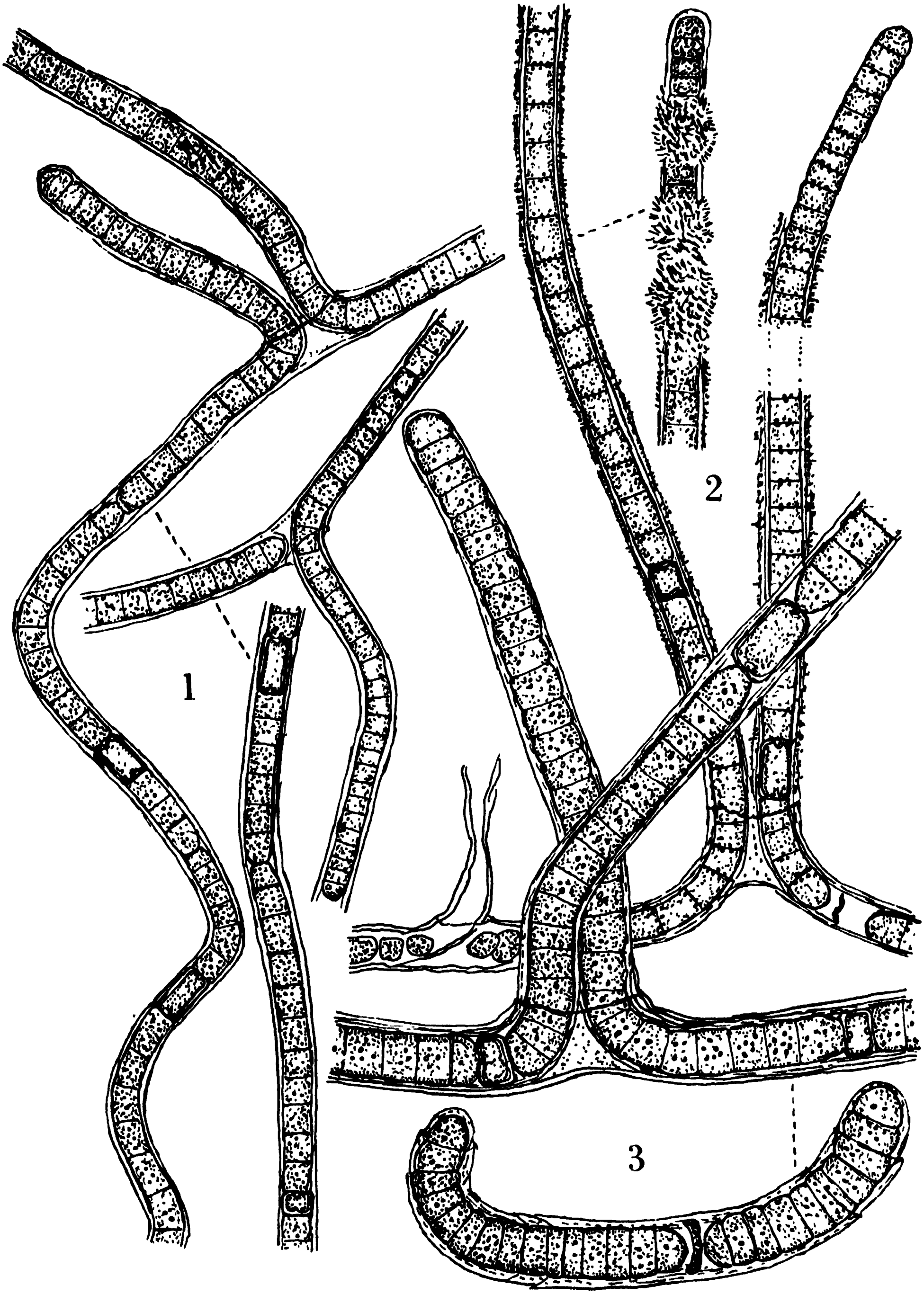

PLATE 87, Figs. 1–3.

1. *Scytonema bohneri* Schmidle; 2. *S. julianum* (Kütz.) Menegh.; 3. *S. guyanense* v. *minus* (all after Skuja).

the cross-walls; cells ⅓ as short as broad, in old filaments nearly as long as broad; heterocysts depressed or quadrate, short cylindrical, or elliptical, single or many.

In swamps, tanks, on submerged walls, on rocks, in streams and in temporary microphytoplankton of straggling portion of rivers. — Calcutta (Martens, 1871a, 177; Prain, 1905, 333; Biswas, 1942, 196/197), Mayphlong in Assam (Biswas, 1934, 15), Nettayam in Travancore (Parukutty, 1940, 119), Shembaganur in Madras state (Frémy, 1942, 22); Lahore in Pakistan (Ghose, 1924, 343); and in Burma (Skuja, 1949, 35).

### 4. **Scytonema simplex** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 157, fig. 1A, B, 1934.

Pl. 89, Fig. 1

Thallus thick, dirty blue-green or pale blue-green; filaments 14–15.7 μ broad, irregularly bent and loosely entangled; false branches long, geminate and single in equal numbers; sheath firm up to 2.1 μ thick, hyaline, unstratified; trichomes sometimes with indistinct septa and occasionally with slight constrictions at the joints, 9.4–11.5 μ broad; cells usually elongate cylindrical up to four times as long as broad, sometimes quadratic, at the growing region flattened and barrel-shaped; heterocysts single, sometimes in pairs, usually elongate, cylindrical, rarely more or less quadratic, with convex end walls thicker than the longitudinal ones, as broad as the trichome, 9.4–11.5 μ broad and 11.5–46.2 μ long.

Floating in a tank on road between Kandy and Anuradhapura, Ceylon (Bharadwaja, *loc. cit.*).

### 5. **Scytonema coactile** Montagne ex Born. et Flah.

Montagne in Kützing Species Algarum, 305, 1849; Bornet and Flahault, Revision des Nostocacées hétérocystées, 90, 1887; Forti in De Toni, Sylloge Algarum, 5: 501, 1907; Frémy, Myxo. d'Afr. équat. franc., 300, fig. 258, 1928; Geitler, Kryptogamenflora, 753, fig. 479, 1932.

Pl. 90, Fig. 2

Thallus radially expanded, woolly, caespitose, green or blue-green, up to 15 cm broad; filament 18–24 μ broad, 4 cm or more long; false branches long, erect; sheath firm, membranaceous hyaline or yellowish; trichome 12–18 μ broad; cells subquadrate or longer than broad; heterocysts sparse, subquadrate.

Free-floating in a tank, Benaras (Rao, C. B., 1937b, 355), on stones in water at the edges of a pond, Palacol in Andhra State (Rao, C. B., 1938a, 87),

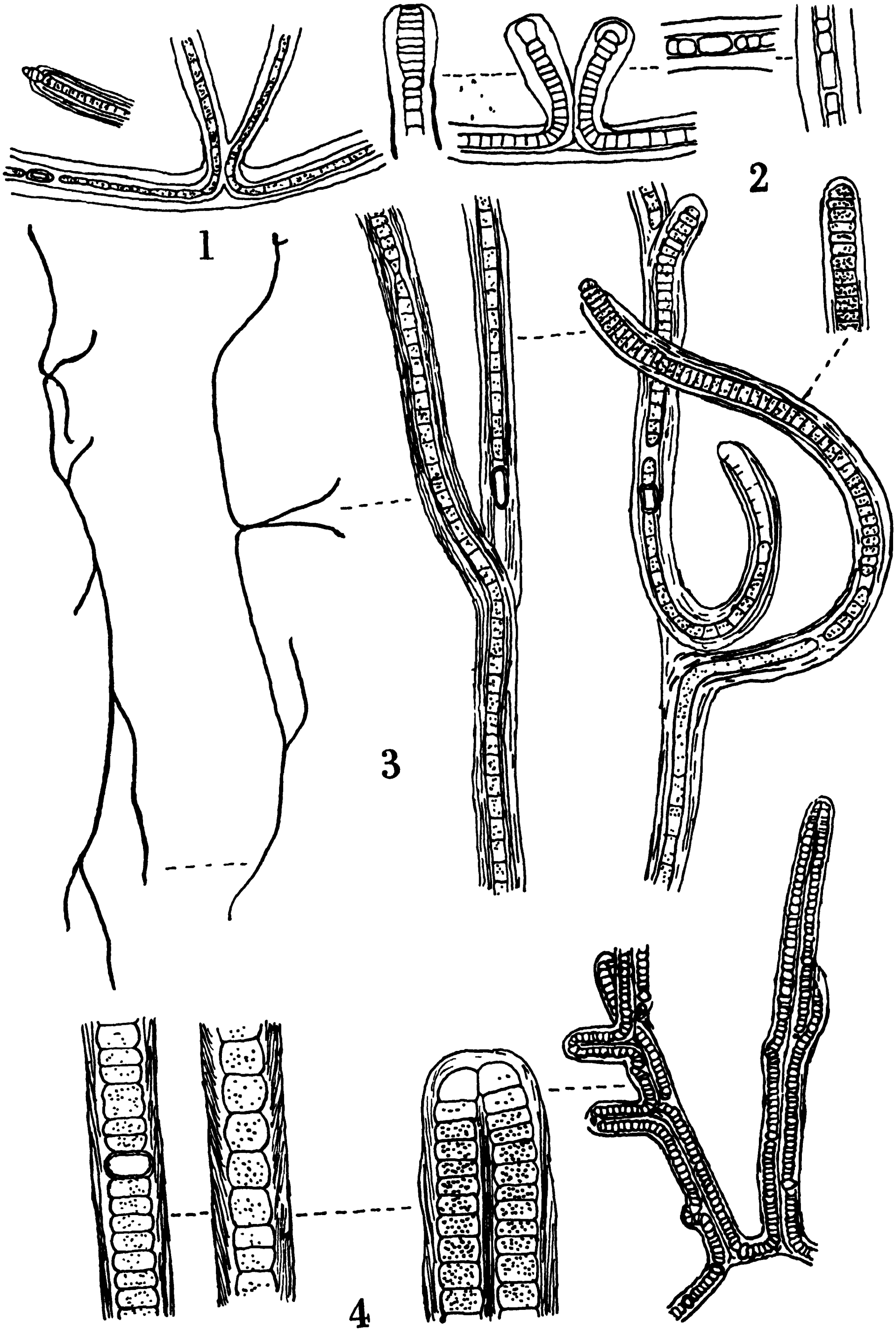

PLATE 88, Figs. 1–4.

1. *Scytonema subtile* Moeb. (after Moebius); 2. *S. subtile* Moeb. (after Woronichin); 3. *S. tolypothrichoides* Kütz. (after Kossinskaja); 4. *S. crustaceum* Ag. (after Geitler).

in the environs of Shembaganur, Madras state (Frémy, 1942, 22) and attached to rocks near a spring, Nettayam in Travancore (Parukutty, 1940, 119).

The filaments in the Indian algae are 16.5–19.8 μ broad and up to 23 μ broad when old, the sheath 2–4 (–4.8) μ thick, the trichomes (7–) 10–15 μ broad, and the heterocysts 12–16.5 μ broad and 11.8–23 μ long.

Skuja (1949, p. 35) has described a form growing on soil, University estate, Rangoon in Burma. This form differed from the type in the generally thick, lamellated and colourless sheath in which aspect it also differs from *S. rivulare* Borzi.—Filaments long, densely entangled, 17–22 μ broad; profusely branched, branches long and arising prominently erect from the main filament, single or geminate; sheath up to 3 μ thick, with more or less distinct parallel lamellation, mostly colourless, seldom yellowish; trichome 13–15 μ broad, not constricted or slightly constricted in the meristernatic end portions, cells in older portions as long as broad, also longer or shorter, in the meristematic zones ½ as long as broad and here the septa often granulated. In the thickness of the sheath the Indian algae agree with the Burmese one. But the details of lamellation etc. are lacking in their accounts.

### 6. **Scytonema leptobasis** Ghose

Five more myxophyceae from Burma, J. Indian bot. Soc., 10 (1): 35–37, figs. 3–5, 1931.

Filaments about 14 μ broad, occasionally false branched; sheath thick, colourless or yellowish brown, lamellated; trichomes about 3 μ thick, at the tip up to 10 μ broad; cells cylindrical, generally longer than broad, false branches swollen at the tips, apex rounded; heterocysts usually single, intercalary, cylindrical, 5–6 μ broad and 8–10 μ long.

On aquatic plants in stagnant water, Maymyo, Burma (Ghose, *loc. cit.*).

### 7. **Scytonema bohneri** Schmidle

Beitr. z. Algenfl. Afrikas, Engler's Bot. Jahrb., 30: 60, 1901; Forti in De Toni, Sylloge Algarum, 5: 501, 1907; Frémy, Myxo. d'Afr. équat. franc., 302, 1929.

Pl. 87, Fig. 1

Stratum filamentous, blackish green; filaments partly creeping, partly ascending, filaments 10–12 μ broad, false branched, branches mostly single, generally narrow 8–19 (–11) μ diam., 200–300 μ long, narrower at the apex, 6–7 μ diam.; sheath colourless, 1–1.8 μ thick, homogeneous, sometimes divergent; trichome bluish green, 5–8 μ broad; cells rectangular, short at the apices, ½ to 1½ times as long as broad in the rest; heterocysts compressed, ellipsoidal to rectangular, longer than broad, wall hyaline.

On soil, University estate, Rangoon, Burma (Skuja, 1949, 34); Red Hills lake Madras (!).

Skuja (1949) describes the species in great detail. — Filaments 8–11 μ broad; sheath up to 2 μ thick, mostly colourless, firm, unlamellated, to slightly lamellated, when old outer portions gelatinizing and becoming somewhat yellowish in the exposed portions; trichomes 6–8 μ broad, not constricted at the cross-walls, seldom constricted at the growing regions, indistinctly granulated at the cross-walls; heterocysts 6–8 μ broad and 5–16 μ long.

### 8. **Scytonema fritschii** Ghose

A Systematic and Ecological Account of Collection of blue-green Algae from Lahore and Simla, J. Linn. Soc. Bot. Lond., 46: 342, pl. 31, fig. 11, 1924; Geitler Kryptogamenflora, 755, fig. 480, 1932.

Pl. 95, Fig. 1

Thallus floccose, greenish brown; filaments thin, elongate, 15–20 μ broad; trichome 7–10 μ broad; cells mostly twice as long as broad, cross-walls distinct, cell contents granular; false branches geminate, remote, as broad as the main filament; sheath firm, parallel lamellation, hyaline; heterocysts intercalary 8–12 μ broad, single, cylindrical and up to 35 μ long or sometimes two to four and quadrate.

Adhering to the submerged sides of tanks, Lahore in Pakistan (Ghose, *loc. cit.*); in the stagnant portions of a stream at Tirupati ( ! ) and in a tank at Bangalore ( ! ).

Bharadwaja (1933) amended the diagnosis of species based on an examination of the type material and the description given above is after Bharadwaja. Bharadwaja described two forms, *a* and *b* from a tank at Vandalur near Madras. His second form has broader trichomes and heterocysts. Rao, C. B. (1938a, 87) has also reported from a pond in Ellore, Andhra Pradesh an alga which resembles form *b*.

Forma *a*. Filaments 14.7–16.8 μ broad; sheath 2.1–3.1 μ thick, usually hyaline, rarely coloured yellow brown, trichomes (5.3–) 8.4–9.4 μ broad, heterocysts (6.3–) 8.4–10.5 μ broad and 8.4–37.8 μ long.

Forma *b*. Filament 16.8–18.9 (–21) μ broad; sheath 1.752.1 (–3.1) μ thick, usually hyaline, sometimes coloured yellow; trichomes (4.2–) 8.4–10.5 (–12.6) μ broad; heterocysts 9.4–14.7 μ broad and 16.8–46.2 μ long, always single.

### 9. **Scytonema caldarium** Setchell

Notes on Cyanophyceae III, Erythea, 7: 48, pl. 3, fig. 3, 1899; Forti in De Toni, Sylloge Algarum, 5: 508, 1907; Geitler, Kryptogamenflora, 754, 1932.

Stratum tufted, expanded, adhering to rocks; filaments at base horizontal and decumbent, more or less intertwined, about 16 μ diam., filaments false branched, false branches generally geminate, erect, in caespitose simplocoid, fascicles; trichomes 4–8 μ broad, olivaceous or yellowish green; cells ½–3 times as long as broad; heterocysts colourless, at first discoid, later quadrate; sheath solid, lamellated, parallel lamellation, colourless, later light yellowish brown.

On the barks of various trees among mosses and lichens, Maymyo and Madaw islands (Ghose, 1927c, 247; 1927d, 254).

### 10. **Scytonema stuposum** (Kützing) Bornet ex Born. et Flah.

Bornet in Bornet and Thuret, Notes algoligiques, 2: 146, 1880; Bornet and Flahault, Revision des Nostocacées hétérocystées, 92, 1887; Forti in De Toni, Sylloge Algarum, 5: 503, 1907; Frémy, Myxo. d'Afr. équat. franc., 303, fig. 260, 1929; Geitler, Kryptogamenflora, 756, fig. 482, 1932.

Pl. 93, Fig. 4

Thallus broadly expanded, tomentose, blackish-violet to reddish; filaments 5–10 mm long, 16–30 μ generally 18–21 μ broad, false branched; false branches nearly resembling the main filaments, single or geminate; sheath thick, gelatinous; trichome olive-violet, when dry greenish, 12–18 μ broad; cells ½–⅓ shorter than broad, subquadrate; heterocysts as broad as the vegetative cells.

On moist soil etc. — Ceylon (Ferguson's Colln., in Bornet and Flahault, 1887, 93), Saranath in Uttar Pradesh (Rao, C. B., 1937b, 355), Tiruvala in Travancore (Parukutty, 1940, 119) and Kumili near Shembaganur, Madras state (Frémy, 1927, 46/47).

The sheath in the Saranath alga is 2–4.8 (–6) μ thick, is yellowish brown and stratified, the trichomes are 10–14 μ broad, narrower (8 μ) when old, and the heterocysts are 13.2–15 μ broad and 11.8–19 μ long. The Travancore alga has narrower trichomes (8–9 μ broad) and smaller heterocysts (6.6–8 μ broad and 4.5–9.5 μ long).

### 11. **Scytonema schmidtii** Gom.

In Johs. Schmidt, Flora of Koh-Chang, Myxo. hormogon. 124, 1901; Bot. Tidsskr., 24, 210, pl. 5, figs. 1–4, 1901; Forti in De Toni, Sylloge Algarum, 5: 508, 1907; Frémy, Myxo. d'Afr. équat. franc., 306, fig. 262, 1929; Geitler, Kryptogamenflora, 759, fig. 483b, 1932.

Pl. 92, Fig. 1

Thallus extensive, brownish black, crustaceous, tomentose, about 1 mm diam., with wrinkled surface; filaments extremely and irregularly undulated, crisp, intricate, 10–12 μ diam., lower down about 16 μ broad, primarily prostrate, stolon-like, abundantly and repeatedly false branched; sheath yellowish brown, lower down broad and rugose, not coloured blue by chlor-zinc-iodide; trichomes extremely torulose, bluish, 9–12 μ broad; cells compressed, subquadrate 2–6 μ long; heterocysts quadrate to compressed, colourless.

On dripping rocks, Kodaikanal ( ! ).

The trichomes are thinner (3.9–) 5.2–8 μ in the Kodaikanal material. The heterocysts are 6.6–9.2 μ broad and the filaments are 10.5–13.1 (–19.7) μ broad.

### 12. **Scytonema millei** Bornet ex Born. et Flah.

Bornet in Bornet and Thuret, Notes algologiques, 2: 147, 1880; Bornet and Flahault, Revision des Nostocacaées hétérocystées, 93, 1887; Forti in De Toni, Sylloge Algarun 5: 505, 1907; Frémy, Myxo. d'Afr. équat. franc., 306, fig. 261, 1929; Geitler, Kryptogamenflora, 757, figs. 483a and 484, 1932.

Pl. 93, Figs. 2, 3

Thallus woolly, cushion shaped, broadly expanded, 1–5 mm high, dull green or brownish; filaments 15–21 μ broad, interwoven, false branches erect; sheath firm brownish, when old with parallel lamellation; cells 10–15 μ broad, discoid, when old becoming elongated up to as long as broad; heterocysts mostly discoid, somewhat broader than the trichome.

Not recorded.

Bharadwaja (Rev. algol., Paris, 7: 169, 1933; Pl. 98, Fig. 6) describes a form.

Filaments narrower than the type, (8.9–) 12.6–15.6 μ broad; sheath 1.5–3. 2–5.2 μ thick; trichome narrower than the type, (6.8–) 8.4–10.5 (–12.6) μ broad; heterocysts 8.4–11.5μ × 8.2–11.5 μ. On roots projecting into water of a small pond near Hanwella, Ceylon.

### 13. **Scytonema burmanicum** Skuja

Zur Süsswasseralgenflora Burmas, 34, pl. 4, figs. 1–10, 1948.

Pl. 97

Thallus crustaceous, expanded, attached to the substratum, more or less prostrate, olivaceous, bluish brownish green or blackish, about 1–1.5 mm diam.; filaments above for the most part erect, parallel, intertwined, densely aggregated; above up to 11 μ, below 14–16 μ broad; sparsely false branched, false branches solitary or geminate, generally elongate and adpressed; sheath simple with parallel lamellation, about 3 μ thick, colourless to yellow brown; trichome commonly 8–11 μ, rarely 15 μ broad, in older part about 3–4 μ, attenuated, more or less constricted at the cross-walls or unconstricted; cells as long as broad or broader or longer, apical cells rounded, contents bluish-green, olivaceous, or grey-violet, homogeneous, septa not granulated; heterocysts cylindrical to discoid, with slightly rounded apices, 5–16 μ broad, 6–16 μ long; propagation by hormogones and hormocysts formed from the apices of erect branches.

Aerophytic on trees, 10th mile, Prome Road, Kammandine, Burma (Skuja, *loc. cit.*).

14. **Scytonema javanicum** (Kütz.) Bornet ex Born. et Flah.

Bornet in Bornet and Thuret, Notes algologiques, 2: 148, 1880; Bornet and Flahault, Revision des Nostocacées hétérocystées, 95, 1887; Forti in De Toni, Sylloge Algarum, 5: 506, 1907; Frémy, Myxo. d'Afr. équat. franc., 309, fig. 264, 1929; Geitler, Kryptogamenflora, 765, fig. 490, 1932.

Pl. 100, Fig. 4

Thallus cushion-like, 2–4 mm high, deep blue-green to reddish; filament 12–15 μ broad, aggregating in erect tascicles; false branches long flexuous, aggregated; sheath firm, thin, hyaline or becoming yellowish; trichome 9–12 μ broad; cells compressed to quadrate; heterocysts subquadrate.

On moist soil, in stagnant pools — Ceylon (Ferguson's Colln. in Bornet and Flahault, *loc. cit.*), Bombay (Hansgirg, 1892, 54), Shembaganur ( ? ) in Madras state (Frémy, 1927, 46/47; 1942, 22) and Benaras in India (Rao, C. B., 1937b, 355); Rangoon in Burma (Ghose, 1926, 250; 1927e, 82).

According to Ghose (1926, 250) the Rangoon alga has narrower filament (9–10 μ) broad and trichome (7–9 μ broad). In the Shembaganur alga (Frémy, 1927) the filaments were 16 μ broad and the trichomes 10–11 μ broad.

15. **Scytonema saleyeriense** Weber van Bosse

Siboga. Exped., 31, pl. 1, figs. 1–3, 1913; Geitler, Kryptogamenflora, 762, 1932.

Thallus matted, 1 mm high, blue-green or brownish black; filaments 16–20 μ broad; false branches mostly single as in *Tolypothrix*, seldom geminate; sheath colourless, up to 4 μ broad, lamellated; trichomes 8–12 μ broad, cells shorter than long, seldom nearly quadratic; heterocysts nearly quadratic or longer than broad; hormogones bent semicircularly.

Type not recorded.

Var. **indica** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix,* Rev. algol., Paris, 7: 160, fig. 2E, 1934.

Pl. 89, Fig. 6

Thallus fluffy, brown or brownish green; filaments irregularly curved and loosely entangled, 18.9–21.1 (–25.2) μ broad; false branches of moderate

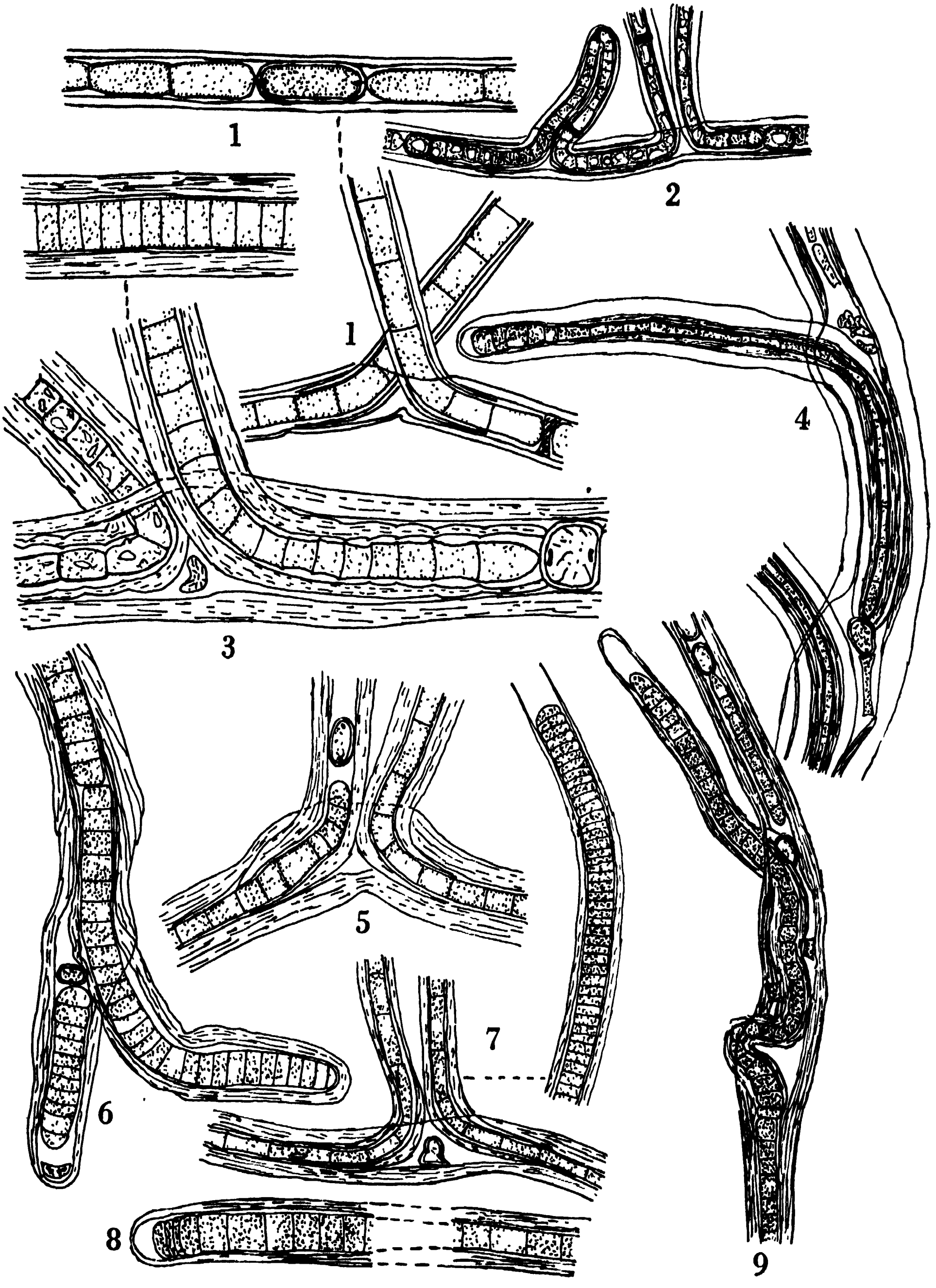

PLATE 89, Figs. 1–9.

1. *Scytonema simplex* Bharadw.; 2. *S. pseudoguyanense* Bharadw.; 3. *S. pascheri* Bharadw.; 4. *S. amplum* West et West; 5, 8. *S. dilatatum* Bharadw.; 6. *S. salayeriense* v. *indica* Bharadw.; 7. *S. iyengari* Bharadw.; 9. *S. guyanense* v. *prolifera* Bharadw. (all after Bharadwaja).

length, usually slightly thinner than the main filament, geminate and single, branches equally numerous; sheath firm, thick, 3.7–5.2 (–7.3) μ thick, pigmented, usually with parallel lamellation, sometimes at the apices and elsewhere with divergent layers, unstained with chlor-zinc-iodide; trichomes (5.7–) 8.4–10.5 μ broad, septa distinct; cells about half as long as broad, or more or less quadratic, very much flattened at the growing apices, in old trichomes cylindrical, and up to twice as long as broad; heterocysts single, subquadratic or slightly flattened, when deformed spherical or subspherical, in old filaments ellipsoidal, up to twice as long as broad, 7.3–11.5 μ broad and 6.3–18.9 μ long.

On barks of trees, Tenmalai (Bharadwaja, *loc. cit.*).

### 16. **Scytonema pascheri** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix,* Rev. algol., Paris, 7: 158, fig. 1C & D, 1934.

Pl. 89, Fig. 3

Thallus thick, brownish green; filaments irregularly curved and densely entangled, 18.9–22.1 μ broad; false branches few, long, usually geminate only found in the older filaments, slightly narrower than the main filament; sheath firm, 4.2–5.8 (–6.3) μ thick, pigmented, with distinct parallel layers, thinned at the growing apices; trichomes (6.3–) 9.4–10.5 (–11.5) μ broad, non-torulose; cells usually flattened, ½–⅓ times as long as broad, in old trichomes quadratic or cylindrical, up to three times as long as broad; heterocysts few mainly in old and unhealthy filments, intercalary, single, quadratic or ellipsoidal, 9.4–12.6 (–13.6) μ broad and 10.4–18.9 (–21) μ long.

On moist soil, Madras (Bharadwaja, *loc. cit.*) and Delhi (Rao, C. S., 1940, 127).

Rao's alga is a little different. It has narrower filaments (13.2–16.5 μ broad) sheath (1.8–2 (–6) μ thick) and trichomes 8–10 (–13.2) μ broad, and smaller heterocysts (8–10 μ broad and 9.9–16.8 μ long).

### 17. **Scytonema hansgirgi** Schmidle

Einige neue von Prof. Dr. Hansgirg in Vorderindien gesammelte Süsswasseralgen, Allgm. bot. Zeitschr., 78, 1900a; Hedwigia, 39: 184, pl. 9, fig. 17, 1900b; Forti in De Toni, Sylloge Algarum, 5: 510, 1907; Geitler, Kryptogamenflora, 764, fig. 489, 1932.

Thallus black, filaments crisp, curved or bent short, fragile, false-branched, false branches short, single, rarely geminate, prostrate or erect, 12–18 μ broad, apex not attenuated, broadly rounded; sheath thin, yellowish brown, fragile, doubling with age, close to the trichome; trichome cylindrical, 10–16 μ

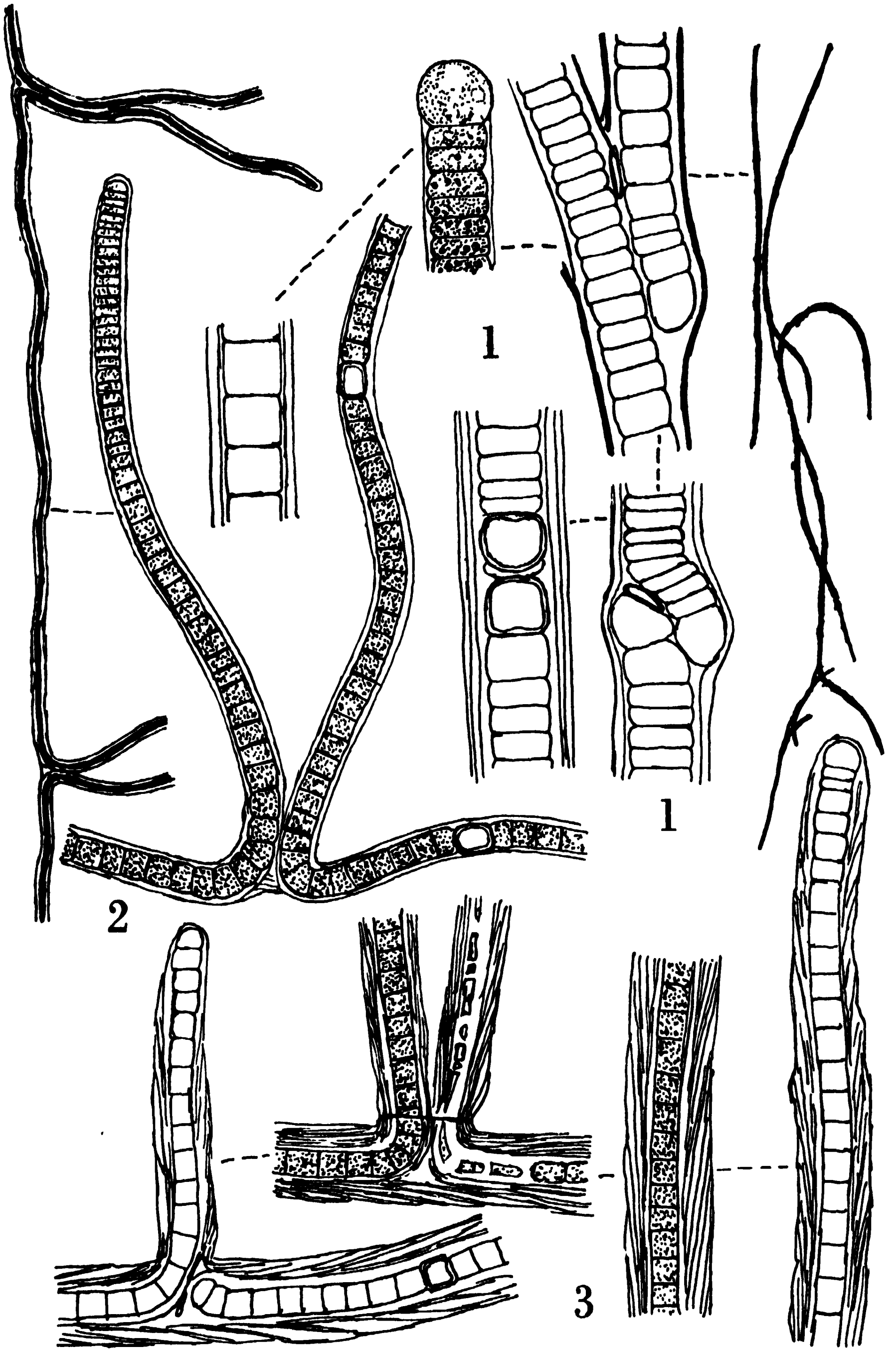

PLATE 90, Figs. 1–3.

1. *Scytonema chiastum* Geitler (after Geitler); 2. *S. coactile* Mont. (after Frémy); 3. *S. myochrous* (Dillwyn) Ag. (after Geitler).

broad, not constricted; cells rectangular, 4–8 times shorter than broad, 2–4 μ rarely 8 μ long, cell contents blue-green, finely granular; heterocysts sparse, short, rounded, as broad as the trichome, yellowish.

On the barks of trees, near Poona (Schmidle, *loc. cit.*).

### 18. **Scytonema iyengari** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 159, figs. 2 C, D, 1934.

Pl. 89, Fig. 7

Thallus thick, dirty green or brownish green, filaments irregularly bent and densely entangled, 15.7–23.1 μ broad; false branches few, usually short, single, and geminate in equal numbers, only formed in older filaments; sheath firm, moderately thick, 2.1–4.2 (–8.3) μ thick, pigmented with distinct parallel stratification, gradually thinning towards the growing apices; stained violet by chlor-zinc-iodide; trichomes 9.5–14.7 μ broad, slightly broadened at the growing apices, and with occasional slight constrictions at the joints, when old narrowed down to 2 μ broad; cells normally flattened, ½–⅓ times as long as broad; heterocysts almost quadratic or cylindrical, usually slightly longer than broad, as broad as the trichome, when old greatly elongated and up to twice as long as broad.

On moist rocks amongst other Myxophyceae in a jungle at Hantana, above Peradiniya, Ceylon (Bharadwaja, *loc. cit.*).

Singh, V. P. (1941, 251) describes a form growing on stones in the seceding portion of River Ravi, Punjab.—Filaments 19.2–23 μ broad, false branches many, not necessarily short; sheath 2.1–4 μ thick not stained by chlor-zinc-iodide; trichome 11.5–15.4 μ broad, cells 8–13.4 μ long; heterocysts 11.5–13.5 μ broad and 17.2–51.8 μ long.

### 19. **Scytonema dilatatum** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 161, fig. 2A, B, 1934.

Pl. 89, Fig. 5

Stratum thin, woolly, blue-green crust, filaments irregularly curved and rather densely entangled, 14.6–18.9 (–25.2) μ broad; false branches few, moderately long, usually single, sometimes geminate; sheath firm, thick, pigmented with parallel stratification, unstained by chlor-zinc-iodide; 3.1–4.2 (–8.4) μ thick; trichomes gradually broadening towards the growing apices with sometimes indistinct septa, 8.4–9.5 μ broad, at the apices up to 10–5 μ rarely 12.6 μ broad; cells almost quadratic, sometimes flattened especially at the growing apices, in old trichomes cylindrical and much longer than

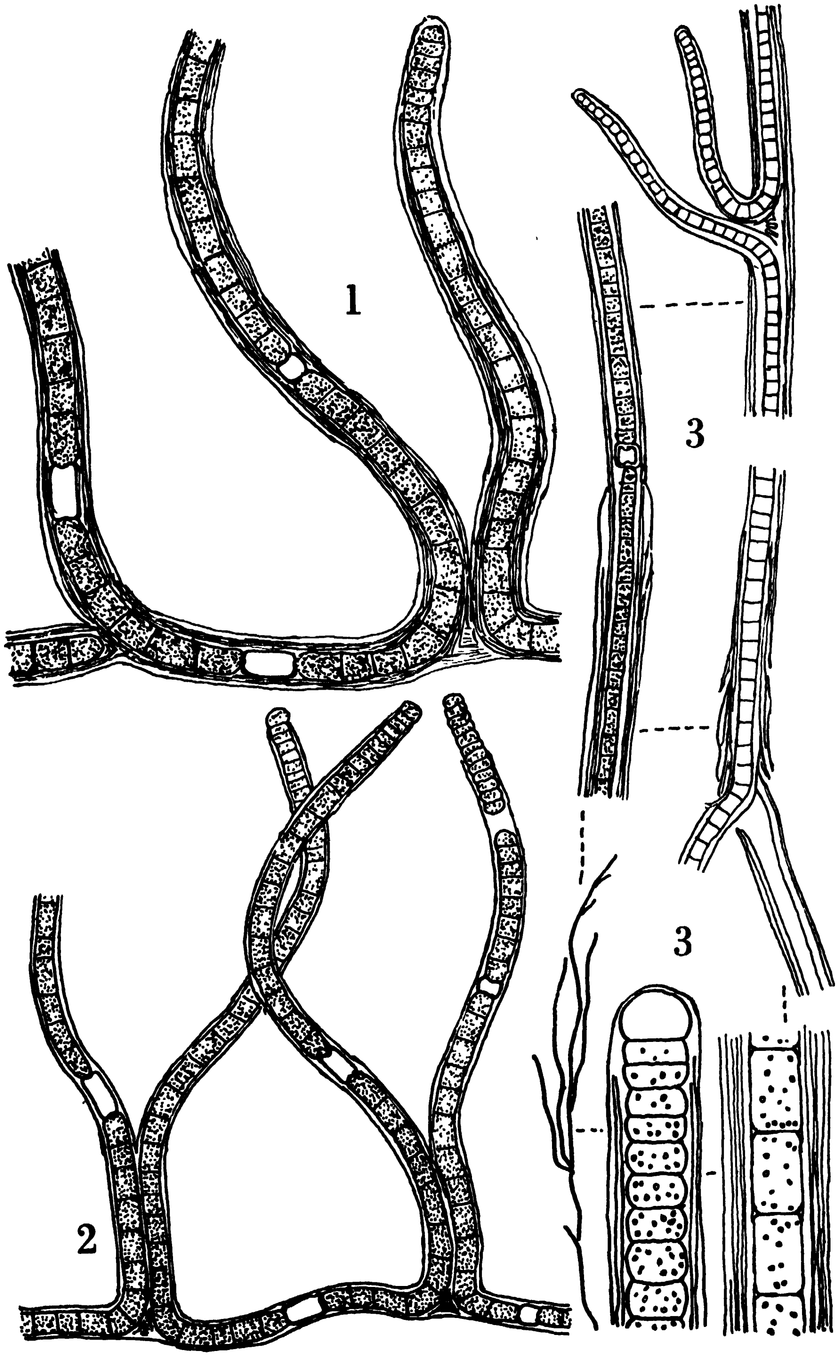

PLATE 91, Figs. 1–3.

1. *Scytonema tolypothrichoides* Kütz. (after Frémy); 2. *S. hofmanni* Ag. (after Frémy); 3. *S. mirabile* (Dillwyn) Ag. (after Geitler).

broad; heterocysts ellipsoidal, when deformed rounded or flattened, 5.2–11.5 μ broad and 5.2–19 μ long.

On soil of an embankment in Expt. station at Gangarrowa, Ceylon (Bharadwaja, *loc. cit.*).

f. **major** Bharadwaja

*loc. cit.*, 163, 1934.

Filaments 20–26 (–29.4) μ broad, branches usually geminate; sheath 3.1–5.2 (–8.4) μ, stained violet by chlor-zinc-iodide; trichome 12–14.7 μ broad at the growing apices up to 16.8 μ broad, when old narrowed down to 9.4 μ; heterocysts 12–14 μ broad and 12–23.1 μ long.

On moist rocks in jungle at Hantana near Peradiniya, Ceylon (Bharadwaja, 1934, 161).

20. **Scytonema ocellatum** Lyngbye ex Born. et Flah.

Lyngbye, Hydrophytologia Danica, 97, pl. 28a, 1819; Bornet and Flahault, Revision des Nostocacées hétérocystées, 95, 1887; Forti in De Toni, Sylloge Algarum, 5: 509, 1907; Frémy, Myxo. d'Afr. équat. franc., 308, fig. 263, 1929; Geitler, Kryptogamenflora, 763, fig. 488, 1932; Frémy, Cyano. cotes d'Eur., 169, pl. 53, fig. 3, 1933.

= *Scytonema cinereum* Meneghini, Conspectus Algologiae Euganeae, 13, 1837.

= *Scytonema murale* Zeller in J. Asiatic Soc. Bengal, 42(2): 182, 1873a.

Pl. 92, Fig. 3

Thallus cushion-like, blackish or greyish blue; filaments 10–18 μ broad, up to 3 mm long, intricate; false branched, false branches short, not agglutinated; sheath firm, brownish often lamellated; trichome 6–14 μ broad, olive green, not torulose; cells shorter than broad or quadrate; heterocysts subquadrate, yellowish.

On moist soil, wall, rocks, on barks of trees and in rivers.—Himalayas (Dickie, 1882, 23), Rajmahal (Martens, 1871a, 171), Mahabaleshwar and Poona (Schmidle, 1900b, 161), Calcutta (Bruhl and Biswas, 1923, 14; Biswas, 1932, 37; Banerji, 1938, 97; Biswas, 1942, 197), Fyzabad and Lucknow (Bruhl and Biswas 1923, 14) Shembaganur and monts Travance (Frémy, 1927, 46/47), Bombay (Dixit, 1936, 100), Benaras (Rao, C. B., 1937b, 355), Puri (Rao, C. B., 1938b, 162), and Trivandrum (Parukutty 1940, 119) in India; Rangoon (Zeller, 1873a, 173; 1873b, 182; Skuja, 1949, 39) and Kya-eng, Pegu (Zeller, 1873b, 181) in Burma; Ceylon (Ferguson's Colln. in Bornet and Flahault, *loc. cit.*) and Nalanda (Bharadwaja, 1934, 161).

Bharadwaja (1934, 161) describes a form growing on rocks near a tank at Nalanda, Ceylon. This differs from the type in the divergent stratification of the sheath.—Filament 14.7–15.7 μ broad, when old down to 12.6 μ broad; sheath 2.6–3.1 (–3.6) μ thick; trichome 8.4–9.4 μ, when old down to 6.3 μ; heterocysts 8.4–11.5 μ broad and 4.2–11.5 μ long.

f. **minor** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix,* Rev. algol., Paris 7: 161, 1934.

Filaments 8.4–11.5 μ broad, when old up to 14.7 μ broad; sheath 1.6–3.1 μ thick, when old up to 3.6 μ thick; trichome 5.2–6.3 μ broad; heterocysts 5.2–7.3 μ broad and 3.1–9.4 μ long.

On rocks round about pools near tank at Nalanda, Ceylon (Bharadwaja, *loc. cit.*).

Singh, R. N. (1942, 50) gives a complete description of this form which is somewhat different from the original diagnosis and is based on an alga collected growing on lawns in the Botanical Gardens at Benaras.—Filaments 2–5 mm in length, 9–11.8 μ broad, when old 11.8–14.7 μ broad; sheath slightly lamellose, 1.5–4 μ thick; trichomes 8.8–11.0 μ broad; heterocysts 5.5–8.8 μ broad and 6.0–8.8 μ long.

It appears as though Singh's form is more like the type of the species itself than forma *minor* Bharadwaja. Singh has worked out the autecology of this alga.

Var. **capitatum** Ghose

On a collection of Myxophyceae from Mergui and some neighbouring islands, J. Burma Res. Soc., 17(3): 247, pl. 3, fig. 7, 1927c.

Pl. 95, Fig. 2

Thallus cushion-shaped, blackish; filament 10–13 μ thick, entangled; sheath firm thick, hyaline when young and yellowish brown and lamellated when old, the outer lamellae being lighter in colour than the inner ones; false branches scarce, not short; trichome 5–8 μ thick, usually swollen at the apex; cells quadrate, yellowish.

On *Hevea brasiliensis*, Kamaw, Kisseraing island, Burma (Ghose, *loc. cit.*).

Var. **purpureum** Gardner

New Myxophyceae from Porto Rico, Mem. N. Y. bot. Gdn., 7: 79, 1927.

Filaments forming a pulvinate or floccose stratum, 1–2 mm thick, 1–1 5mm long, 14–18 μ diam.; cells homogeneous, purplish or pale violet, subquadrate to twice as long as broad, otherwise as in the species.

In soils from rice and wheat field and uncultivated soils, Allahabad (Mitra, 1951, 359/360).

### 21. **Scytonema amplum** West et West

On some freshwater Algae from the West Indies, J. Linn. Soc. (Bot.) Lond., 30; 270, pl. 16, figs. 14–16, 1895; Forti in De Toni, Sylloge Algarum, 5: 512, 1907; Geitler, Kryptogamenflora, 768, 1932.

Pl. 89, Fig. 4

Thallus small, wrinkled, 3–5 mm diam., brownish; filaments densely intricate, 19–24 μ broad; false branches sparse, generally geminate, sometimes single, 13.5–16 μ diam., narrower than the main filament; sheath broad, with parallel lamellation, on the outside gelatinous, and colourless or yellowish in the internal parts abruptly yellowish brown; trichomes 3.5–4 μ broad, yellowish green, apices broad; cells short, cells 3½–6, rarely twice as long as broad; heterocysts oblong, 3–3½ times as long as broad, rarely twice as long.

On rocks splashed with water from a waterfall, Periyar, Madras state (Bharadwaja, 1934, 163).

According to Bharadwaja, the Periyar alga was growing under extreme terrestrial conditions, and his identification was tentative.

Playfair (Plankton of Sydney Water Supply, 533, pl. 56, fig. 13C, 1912) reduced this species to a variety, var. *amplum* (West and West) Playfair under *S. mirabile* (Dillw.) Born.

### 22. **Scytonema pseudopunctatum** Skuja

Zur Süsswasseralgenflora Burmas, 38, pl. 6, figs. 1–9, 1949.

Pl. 96

Thallus pulvinate, expanded, attached to the substratum, not attenuated, olivaceous to blackish, 1–2 mm diam.; filaments partly prostrate, mostly erect, more or less densely intertwined, 15–25 μ broad, false branched, rarely solitary or geminate, generally short; sheath moderately thick, about 4.5 μ thick, with parallel lamellation, close, colourless or yellow or yellowish brown, anterior portion smooth, posterior portion finely and densely granulated; trichomes 13–18 μ broad, commonly constricted at the cross-walls, slightly constricted at meristematic region; cells isodiametric or in parts about 1½ times as long as broad, cell content pale olivaceous or when old grey-violet; homogeneous or sparsely granulated; heterocysts cylindrical with rounded ends, frequently lightly constricted in the middle region or discoid or rounded quadrate, 15–19 μ broad, 8–38 μ long, yellowish membrane; propagation by hormogones and hormocysts formed from the apices.

On the barks of *Zizyphus jujuba*, Rangoon in Burma (Skuja, *loc. cit.*).

### 23. **Scytonema guyanense** (Mont.) Bornet et Flahault

Revision des Nostocacées hétérocystées, 94, 1887; Forti in De Toni, Sylloge Algarum, 5: 506, 1907; Frémy, Myxo. d'Afr. équat. franc., 311, fig. 265, 1929; Geitler, Kryptogamenflora, 770, fig. 493, 1932.

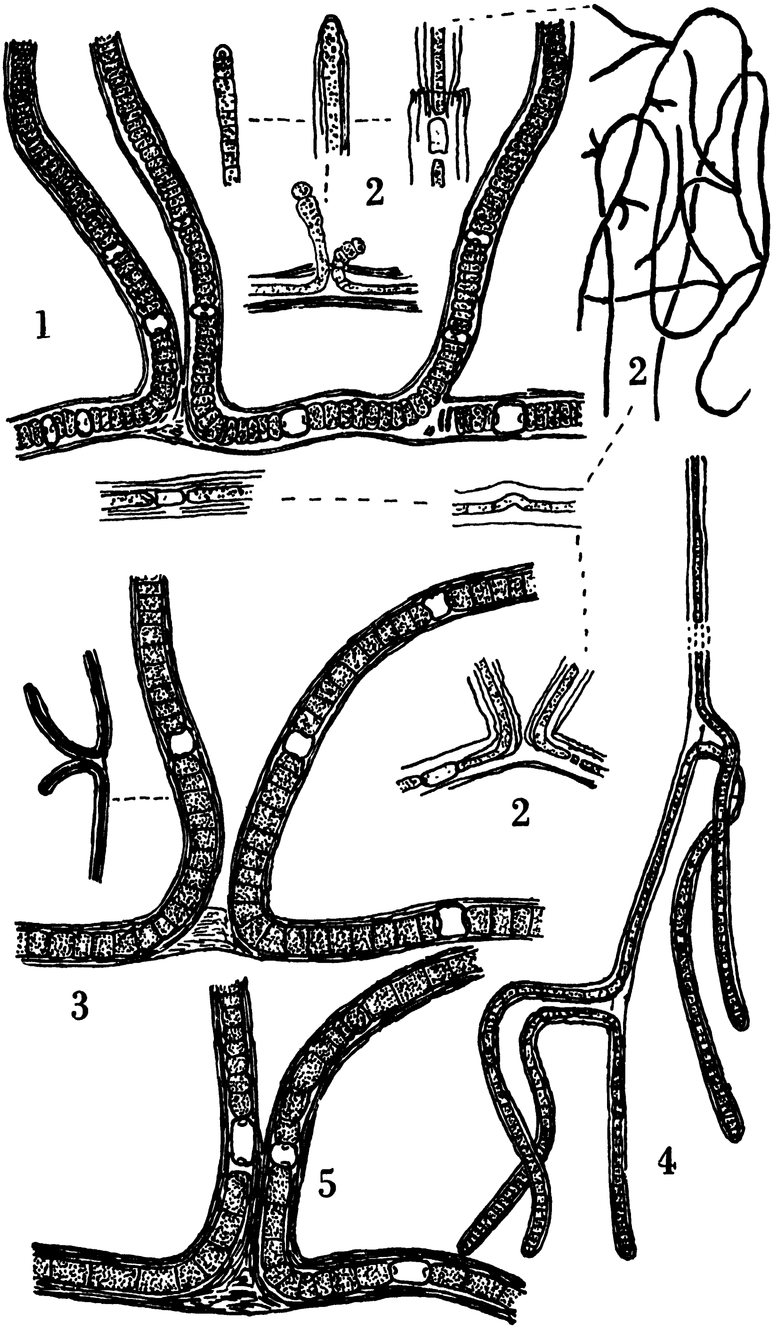

PLATE 92, Figs. 1–5.

1. *Scytonema schmidtii* (after Frémy); 2. *S. bewsii* Fritsch et Rich (after Fritsch & Rich); 3. *S. ocellatum* Lyngb. (after Frémy); 4. *S. multiramosum* Gardner (after Gardner); 5. *S. guyanense* (Mont.) Born. et Flah. (after Frémy).

Thallus expanded, like a cushion, 1–2 mm thick, blackish green, Filaments, (14–) 15–21 μ broad, united in bundles; false branches long, bent, united at the base; sheath firm, lamellated, yellowish, brown; Trichomes 10–16 μ broad; cells quadrate to longer than broad.

On moist surfaces. — Ceylon (Forti, 1907, 506), Mussorie in U. P. (Rao, C. B., 1937b, 356), Polamur in Andhra state (Rao, C. B., 1938a, 87) and Shembaganur in Madras state (Frémy, 1942, 22).

Rao describes the sheath as 2–4 μ thick and the heterocysts 10–14 μ broad and 11–20 μ long.

### Var. **minus** Gardner

New Myxophyceae from Porto Rico, Mem. N. Y. bot. Gdn, 7: 79, 1927.

Pl. 87, Fig. 3

Filaments 12–18 μ diam., long, flexuous, forming a thin, floccose stratum; sheath slightly lamellose, lamellae not divergent; trichomes up to 13 μ diam. at the apices, 6–8 μ in older parts; cells cylindrical, or slightly torulose at the apices, quadrate or less at the apices of the trichomes, 2–4 times as long as the diameter in the older parts, homogeneous or with a few refringent granules.

In a pool, Hmabi; on Lagerstroemia floribunda, 6th mile Prome Road, Rangoon, Burma (Skuja, 1949, 35).

### Var. **prolifera** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol. Paris, 7: 164, fig. 3C, 1934.

Pl. 89, Fig. 9

Stratum moderately thick, brownish green or yellowish brown curst with tufted growth; filaments irregularly curved and densely entangled, 10.5–11.6 (–16.8) μ broad; false branches long usually single; sheath firm, pigmented, with parallel stratification, 2.1–3.1 (–5.2) μ thick, stained with chlor-zinc-iodide; trichome 5.2–6.3 (–7.3) μ broad; cells quadratic or slightly longer than broad, in older trichomes cylindrical and usually broader than the trichome and closely adpressed to the sheath; 5.2–8.4 (9.4) μ broad and 4.2–18.9 μ long.

On moist walls at Trincomalie, Ceylon (Bharadwaja, *loc. cit.*).

The variety differs in having much thinner trichomes and filaments and in the heterocysts being broader than the trichome.

### 24. **Scytonema pseudoguyanense** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix,* Rev. algol., Paris., 7: 164, fig. 3A, 1934.

Pl. 89, Fig. 2

Thallus a thick cushion, with long erect threads, brownish green, filaments irregularly curved and densely entangled, 15.7–18.9 (23.1) μ broad; false branches numerous, invariably slightly narrower than the filament, forming secondary branches at an early stage, usually geminate often arising as loops; sheath firm, 2.1–3.1 (–4.5) μ thick, rarely 7.3 μ thick, pigmented with parallel stratification; trichomes 8.4–9.5 (10.5) μ broad, when old narrowed down to 5.2 μ; cells almost quadratic, flattened at the growing apices in older parts cylindrical, up to four times as long as broad; heterocysts quadratic or cylindrical, when unhealthy ellipsoidal, 10.5–12.6 μ broad, usually longer than broad, rarely shorter than broad, 7.3–18.6 (–21) μ long.

On moist rocks of Railway cutting, Tenmalai, S. India (Bharadwaja, *loc. cit.*).

Bharadwaja. (The Taxonomy of *Scytonema* and *Tolypothrix,* Rev. algol., Paris, 7: 166, 1934) describes a form.—

Filaments 10.5 μ broad, when old up to 12.6 μ broad; sheath up to 2.1 μ thick, at the growing apices thinned down to 0.75 μ and in the older filaments up to 3.1 μ; trichomes 6.3 μ broad, when old narrowed down to 4.2 μ (sometimes 3.5 μ); heterocysts 6.3–8.4 μ broad and 5.2–12.6 μ long. — On moist rocks of railway cutting, Tenmalai, S. India (Bharadwaja, *loc. cit.*).

### 25. **Scytonema julianum** (Kütz.) Menegh.

ex Kützing, Species Algarum, 197, 1849; Geitler, Kryptogamenflora, 774, 1932.

= *Sc. cinereum* var. *julianum* Rabenh., Fl. Eur. Alg., 2: 248, 1865.

Pl. 87, Fig. 2

Filaments in more or less distinct erect bundles forming a cushion shaped or penicillate thallus, thallus impregnated with calcium, filaments 7.5–12 μ broad, false branches sparse; sheath thin, firm, not lamellated, colorless or yellowish, in older parts densely covered by calcium; trichome 7–9.5 μ broad; cells 2.5–4 μ long, when old as long as broad, blue-green; heterocysts rounded quadrate or rounded cylindrical, sometimes up to 14 μ long.

On sandstones, Yay-gna-Choung, Pegu (Zeller, 1873, 181); Kemmandine, Burma (Skuja, 1949, 36).

This species has often been placed in *Scytonema hofmanni* (*see* Bornet and Flahault, 1887, p. 97). Elenkin and Poljansky (Not. Syst. Instit. Crypt. Horti Botan. Petropol., 1: 184–190, 1922) and Geitler recognise the distinctness

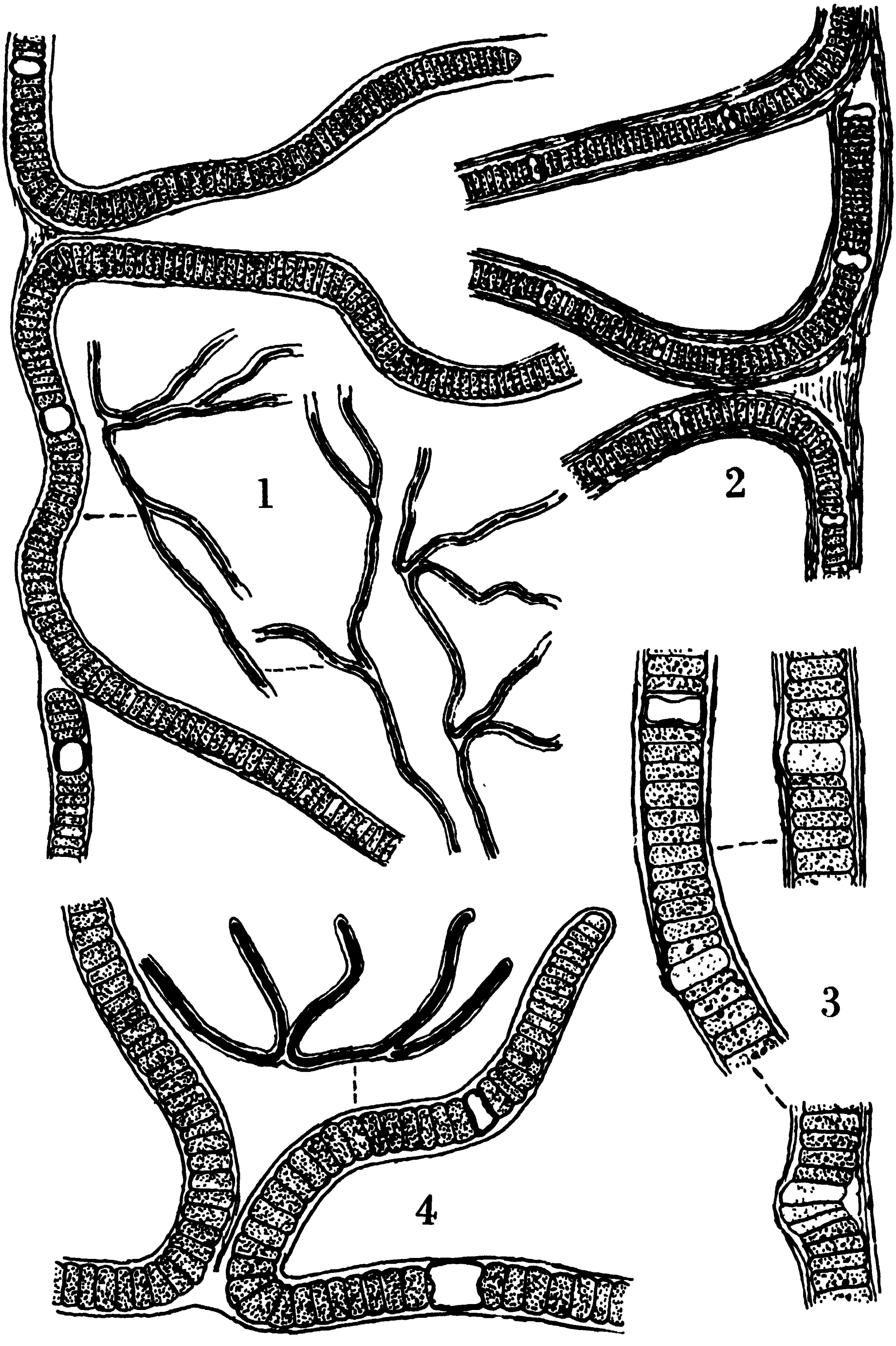

PLATE 93, Figs. 1–4.

1. *Scytonema cincinnatum* Thuret (after Frémy); 2. *S. millei* Born. (after Frémy); 3. *S. millei* Born. (after Geitler); 4. *S. stuposum* (Kütz.) Born. (after Frémy).

of *Sc. julianum.* Elenkin (1938, p. 885) has given valuable evidence based on examination of a number of materials. Elenkin and Poljansky prefer the name *Sc. drilosiphon* (Kütz.) Elenk. and Polj. to *Sc. julianum* (= *Drilosiphon julianus* Kütz.).

### 26. **Scytonema varium** Kütz. ex Born. et Flah.

Kützing, Spec. Alg., 307, 1849; Bornet and Flahault, Revision des Nostocacées hétérocystées, 97, 1887; Forti in De Toni, Sylloge Algarum, 5: 512, 1907; Geitler, Kryptogamenflora, 774, 1932.

Thallus tomentose, 2–3 mm high, blue-green or brownish; filaments tortuous, intricate, 9–15 μ broad, greenish or yellowish; sheath gelatinous, in the lower portion colourless and pellucid, in the upper portions yellowish; trichomes 5–7 μ broad, blue-green or yellowish; cells subquadrate and densely granulated, little distinct; heterocysts subquadrate or longer than broad, colourless.

On moist surfaces or tree trunks, in streams and ponds.—Choung-menah stream and Wa-choung at Pazwon-doung (Zeller, 1873 b, 182; Theobald, 1883, 22), on *Hevea brasiliensis*, Kamaw, Kisseraing island (Ghose, 1927 c, 248) and Maymyo island (Ghose, 1927 d, 254) in Burma; among mosses at Newara Elliya (Zanardini, 1872, 157) and in Ferguson's collections from Ceylon (Bornet and Flahault, *loc. cit.*); Lahore in Pakistan (Ghose, 1924, 342).

In all of Ghose reports the alga has broader trichomes (6–9 μ broad).

### 27. **Scytonema frémyii** nom. nov.

= *Scytonema tenuissimum* Frémy, Cyanophycées de l'Inde méridionale, Blumea, Suppl. II, 35, fig. 9, 1942; *non* Nägeli, *non* Schmidle.

Pl. 100, Fig. 3

Thallus on soil, expanded, greenish black; filaments long, about 9 μ broad, sparsely false branched; false branches geminate, free at the base, long; sheath yellowish at the apices, hyaline, homogeneous, not lamellate, not dilated, and 5 μ thick; trichome constricted at the cross-walls; cells 2–4 times longer than broad, rarely shorter than long; heterocysts rectangular, 4–5 times longer than broad.

On soil in the environs of Shembaganur in Madras State (Frémy, *loc. cit.*).

### 28. **Scytonema schmidlei** J. De Toni

Noterelle di nomenclatura algologica, 8: 6, 1936.

= *Scytonema tenuissimum* Schmidle, Epi. Alg. aus. N. Guin., Flora, 83: 323, 1897; Forti in De Toni, Sylloge Algarum, 5: 512, 1907; *non* Nägeli, *non* Frémy.

Thallus attached to tree trunks or leaves, irregularly bluish or violet, rarely greenish; filaments parallel, 5–6 μ broad, sparsely false branched, false branches single; sheath thin, hyaline; trichome 3–4 μ broad, bluish-green; cells generally 8 μ long to subquadrate; heterocysts rare, yellowish, quadrate, rounded or with rounded angles, as long as broad or 1½ times as long.

Mountains of Tonglu, Burma (Carter, 1926, 269).

### 29. **Scytonema subtile** Möbius

Ein Brasil. Alg. p. 179, and Austr. Süsswasseralg., Flora, 3: 448, 1892; Forti in De Toni, Sylloge Algarum, 5: 505, 1907; Lemmermann, Kryptogamenflora der Mark Brandenburg, 3: 211, 1910.

Pl. 88, Figs. 1, 2

Filaments single, intermingled sparsely among other algae, 12–17 μ broad; false branches geminate, generally narrower than the main filament; sheath colourless, with parallel lamellation; trichome 2–4 μ diam; cells 2–3 times as long as broad, cylindrical; heterocysts oblong, 4 μ diam, 10–14 μ long.

On tree trunks, Mahabaleswar near Bombay (Schmidle, 1900b, 183); in Sikkim Himalayas (Carter, 1926, 269).

### 30. **Scytonema multiramosum** Gardner

Myxophyceae from Porto Rico, Mem. N. Y. bot. Gdn, 7: 81, pl. 18, fig. 39, 1927; Geitler, Kryptogamenflora, 771, fig. 494, 1932.

Pl. 92, Fig. 4

Filaments erect, intertwined into dense fascicles more or less agglutinated by the soft sheath slightly gelatinous, 1.5–2.5 mm long, 9.5–13 μ broad; profusely branched, with geminate false branches in the upper parts of the filament between the heterocyst; trichomes at the apices 7–8 μ broad, in old parts narrowed to 3 μ broad, cells at the apex slightly barrel-shaped, subquadrate, densely granular, other cells 1.5–4 times as long as broad; sheath thin at the apices gradually thickening in older parts, hyaline and homogeneous when young becoming yellowish and lamellated when old, lamellation divergent, slightly ocreate at the apices.

Type not recorded.

#### Var. **ceylonica** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol. Paris, 7: 166, fig. 4C, D, 1934.

Pl. 94, Figs. 3, 4

Thallus a thick dark brown crust, filaments irregularly and loosely entangled, 10.5–12.6 (–13.6) μ broad, when old up to 17.8 μ; false branches usually long, geminate and single; sheath firm of variable thickness, pigmented, with parallel lamellation, lamellae distinct only when coloured, 2.1–3.7 μ thick, usually at the growing apices 1.5 μ thick, in the old filaments up to 5.2 μ thick; trichomes gradually broadening towards the growing apices, 5.2–6.3 μ broad, when old narrowed down to 3.1 μ broad, at the growing apices up to 7.3 μ broad; cells quadratic or cylindrical, at the apical portions flattened or barrel-shaped with constrictions at the joints, in old trichomes or parts of trichome narrower and elongate cylindrical; heterocysts quadratic or cylindrical, rarely slightly shorter than broad, in normal condition usually as broad as the trichome, (4.2–) 5.2–7.3 μ broad and 5.2–12.6 (–23.1) μ long.

On surface of smooth clayey bank at the roadside, Lady Horton's Walk, Nuwara Elliya, Ceylon (Bharadwaja, *loc. cit.*).

### 31. **Scytonema hofmanni** Ag. ex Born. et Flah.

Agardh, Synopsis Algar. Succiee, 117, 1817; Bornet and Flahault, Revision des Nostocacées hétérocystées, 97, 1887; Forti in De Toni, Sylloge Algarum, 5: 513, 1907; Frémy, Myxo. d'Afr. équat. franc., 313, fig. 266, 1929; Geitler, Kryptogamenflora, 772, fig. 495, 1932; Frémy, Cyano. cotes d'Eur., 170, pl. 53, fig. 4, 1933.

= *Scytonema kurzianum* Zeller, J. Asiatic Soc. Bengal, 42(2): 182, 1873.

Pl. 91, Fig. 2

Stratum cushion-like, broadly expanded, 1–3 mm high, blackish blue-green, sometimes impregnated with calcium carbonate, amethyst green or bluish-grey; filaments 7–12 μ broad, rarely up to 15 μ broad, aggregated in vertical fascicles; false branches aggregated; sheath firm, membranaceous; trichome 5–10 μ broad, olive to blue-green, cells unequal in length; heterocysts oblong.

On stones, on soil and on trees.— Yay-gna-Choung, Pegu (Zeller, 1873b, 181), Pegu range (Zeller, 1873a, 172; 1873b, 182; Theobald, 1883, 22) and on trees Kyauktan in Burma (Skuja, 1949, 36); Mahim, Igatpuri, Mahableshwar, Panchgani and Danger Point near Bombay (Schmidle, 1900b, 161), Berkuda island in lake Chilka (Biswas, 1924, 364), Benaras (Rao, C. B., 1937b, 356), paddy-fields of Thana, Goregaon and Dahisar near Bombay (Gonzalves and Gangla, 1949, 53/54), Usar soil from Siwait near Allahabad (Mitra, 1951, 362), and paddy-fields, Allahabad (Gupta, 1953, 306); attached to moist rocks besides a waterfall, Tirupati ( ! ).

### Var. **calcicolum** Hansg.

Phys. u. Alg. Mittheil., pl. 36, fig. 35, 1890; Prodromus der Algenfloras von Böhmens, 33, 1892; Forti in De Toni, Sylloge Algarum, 5: 516, 1907; Geitler, Kryptogamenflora, 772, 1932.

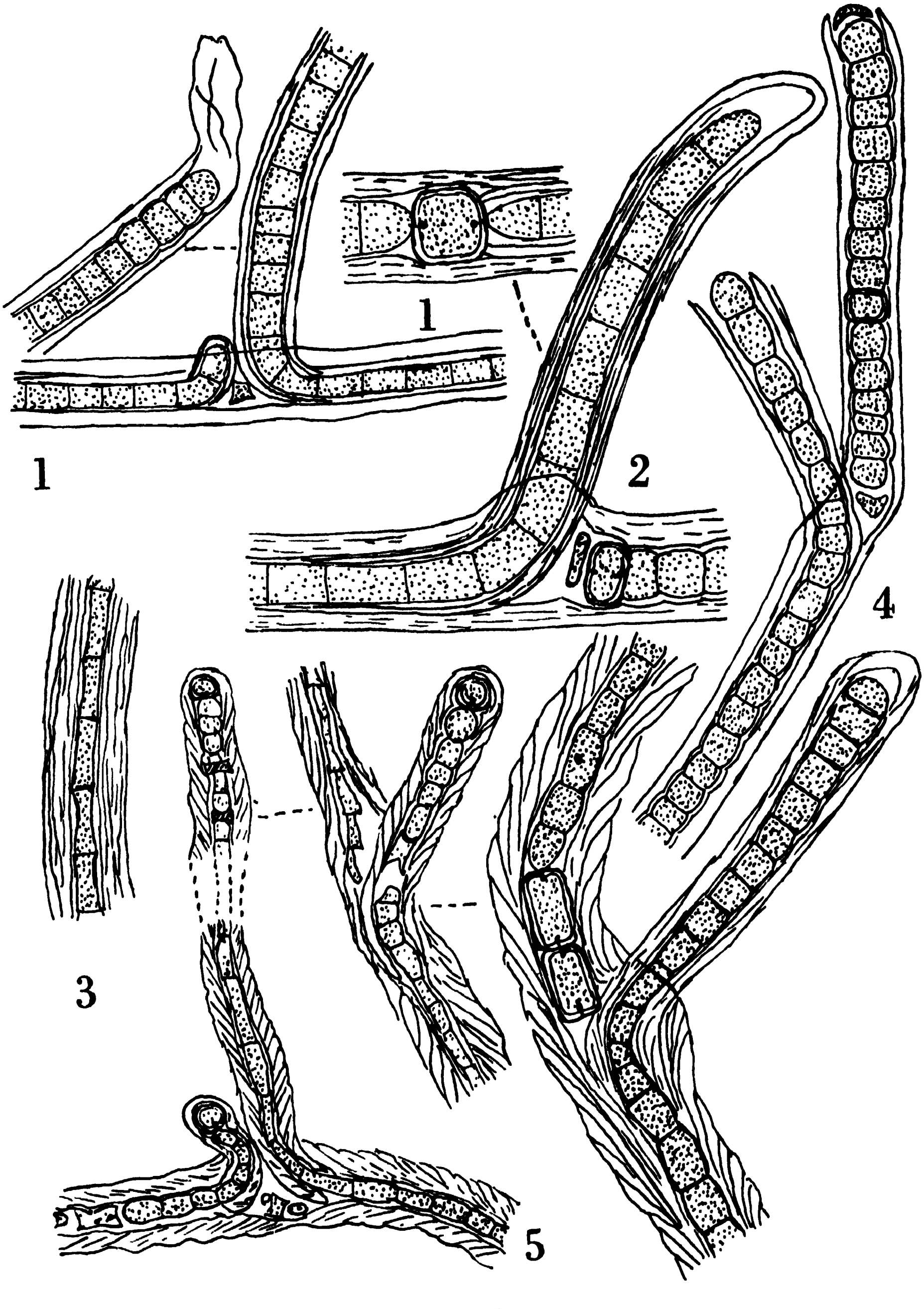

PLATE 94, Figs. 1–5.

1. *Scytonema hofmanni* v. *crassa* Bharadw.; 2. *S. pseudohofmanni* Bharadw.; 3, 4. *S. multiramosum* v. *ceylonica* Bharadw.; 5. *S. geitleri* Bharadw. (all after Bharadwaja).

Stratum smooth, brown or black, rarely almost soft gelatinous, often expanded, growing on calcareous rocks; filaments more or less branched, curved, aggregated into dense floccose masses; false branches somewhat narrower, single or geminate, erect, arising in between heterocysts; sheath close, somewhat thick with age, yellow or yellowish orange, rarely nearly colourless; trichomes 4–6 μ broad, blue-green or yellowish; cells subquadrate or ½ as long as broad; heterocysts subquadrate, single or in two, a little shorter or longer than broad; contents yellowish.

Byculla, Mumbo near Bombay and Mount Lavinia in Ceylon (Schmidle, 1900b, 161; Wille, 1915, 162).

### Var. **symplocoides** (Reinsch) Bornet et Flahault

Revision des Nostocacées hétérocystées, 99, 1887; Forti in De Toni, Sylloge Algarum, 5: 515, 1907; Geitler, Kryptogamenflora, 773, 1932.

Sheath hyaline, trichomes light blue-green.

Poona (Schmidle, 1900b, 161) and Kodaikanal (Frémy, 1927, 46/47).

The filaments in the Kodaikanal alga were 7.5–12 μ broad.

### Var. **crassa** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 167, figs. 4A and B, 1934.

Pl. 94, Fig. 1

Stratum a thick dull blue-green or brownish green, expanded mass; filaments straight or irregularly curved, loosely entangled, 9.4–12.6 μ broad; false branches long, usually narrower than the main filament when young, and short, geminate and single branches equal in number; sheath firm, 2.7–3.7 μ thick, pigmented, with parallel stratification, gradually thinned down towards the growing apices and 0.5 μ thick; trichomes 3.1–4.7 μ broad, gradually broadening towards the growing apices and up to 8.4 μ broad; cells usually cylindrical, sometimes quadratic, in old filaments elongate cylindrical, at the growing apices flattened or barrel-shaped; apical cell almost rounded; heterocysts single, elongate, cylindrical with convex end walls, up to six times as long as broad, when deformed subellipsoidal or subspherical, usually broader than the trichome, 4.2–8.4 μ broad and 6.3–27.3 μ long.

On rocks in water course just below Huxley's tea factory near Peradiniya, Ceylon (Bharadwaja, *loc. cit.*).

### 32. **Scytonema pseudohofmanni** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. Algol., Paris, 7: 167, fig. 4E, F, 1934.

Pl. 94, Fig. 2

Thallus brownish green, expanded with short tufted growth; filaments 8.4–12.6 (–13.6) μ broad, irregularly curved and densely entangled, false-branches few, single and geminate; sheath firm, 1.5–2.6 (–3.6) μ thick, pigmented, with rather indistinct parallel stratification; trichome 5.2–7.3 μ broad, in old filaments narrowed down to 4.2 μ, septa distinct; cells usually cylindrical, sometimes quadratic, flattened and barrel-shaped; heterocysts single, sometimes in pairs, usually broader than the trichome, 5.2–8.4 μ broad, almost quadratic or ellipsoidal, when deformed spherical or transversely ellipsoidal, 5.2–12.6 μ long.

On old walls, Hanwella, Ceylon (Bharadwaja, *loc. cit.*).

Bharadwaja (*loc. cit.*, 169, 1934) describes a form.—

Filaments 9.5–12.6 (–14.7) μ broad; sheath 2.1–2.6 μ, in old filaments up to 5.7 μ thick; trichome 5.2–7.3 μ broad, when old narrowed down to 2.1 μ broad; heterocysts 5.2–7.3 μ broad and 7.3–21.0 μ long.—On walls along one of the upper roads, Trincomalee, Ceylon.

### 33. **Scytonema tolypothrichoides** Kützing ex Born. et Flah.

Kützing, Species Algarum, 307, 1849; Tab. phycologicae, 2: 6, pl. 22, fig. 4, 18; Bornet and Flahault, Revision des Nostocacées hétérocystées, 100, 1887; Forti in De Toni, Sylloge Algarum, 5: 516, 1907; Frémy, Myxo. d'Afr. équat. franc., 317, fig. 267, 1929; Geitler, Kryptogamenflora, 779, fig. 500, 1932.

Pl. 88, Fig. 3 & Pl. 91, Fig. 1

Thallus caespitose, floating, 1 cm high, brownish green; filaments 10–15 μ broad, radiating, 5–6 mm long, repeatedly false branched, false branches very similar to main filament; sheath hyaline, later orange brown, lamellated, outermost lamellae often colourless; trichome 8–12 μ broad, olivaceous-yellow; cells subquadrate or longer, densely granulated, scarcely distinct; heterocysts varied, sometimes short, and some long, rose coloured.

On barks of trees, Calcutta (Bruhl and Biswas, 1923, 15; Banerji, 1938, 97); in hot springs (37°C) at Vajreshwari near Bombay (Gonzalves, 1947, 25).

Bruhl and Biswas (1923, 15) described that the trichomes in their Calcutta alga was narrower (6–9 μ broad; 6–10 μ broad in Banerji, 1938).

### f. **terrestris** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. Algol. Paris, 7: 170, 1934.

Filaments 12.6–18.9 (–21.9) μ broad; sheath 2.1–4.2 (–5.2) μ thick; trichomes 8.4–10.5 (–11.5) μ broad, when old becoming narrower and 6.3 μ broad; heterocysts 8.4–12.6 μ broad and 5.2–16.5 (–19.8) μ long.

On tree trunks, Mount Pedro, Nuwara Elliya, Ceylon (Bharadwaja, *loc. cit.*).

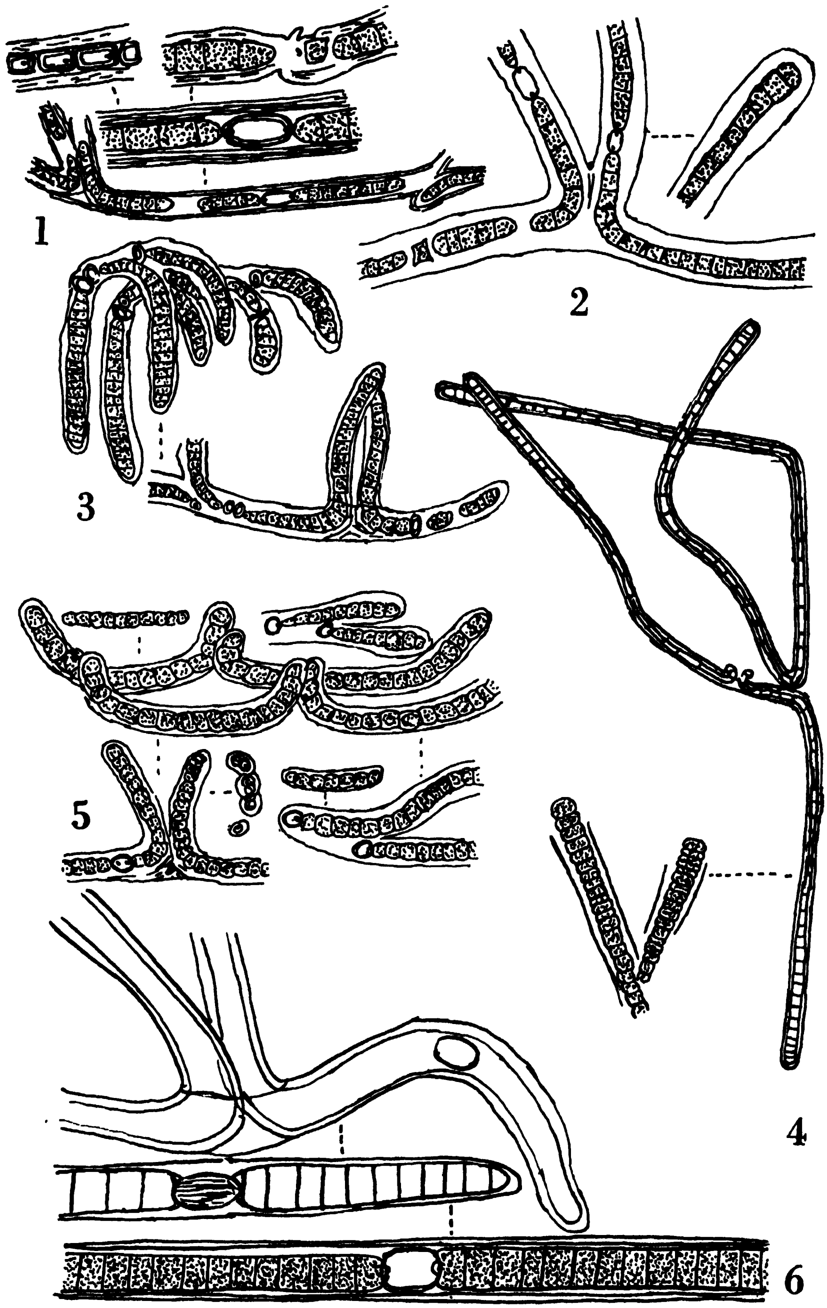

PLATE 95, Figs. 1–6.

1. *Scytonema fritschii* Ghose (after Ghose); 2. *S. ocellatum* var. *capitatum* Ghose (after Ghose); 6. *S. zellarianum* Bruhl et Biswas (after Bruhl & Biswas); 3. *Tolypothrix conglutinata* v. *colorata* Ghose (after Ghose); 5. *T. campylonemoides* Ghose (after Ghose); 4. *Pseudoscytonema malayense* (Biswas) Elenkin (after Biswas).

### 34. **Scytonema geitleri** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 172, fig. 6, 1934.

Pl. 94, Fig. 5

Thallus moderately thick, a brownish or dark green, mucilaginous crust; filaments 10.5–12.6 (–24) μ broad, irregularly curved, densely entangled below but subparallel above; false branches in moderate number, narrower than the main filaments, geminate and single, both short and long, short branches usually club-shaped; sheath firm, 3.1–4.2 (–7.8) μ thick, pigmented, outer surface wavy and uneven and in old filaments the inner ones also uneven and following the contour of the swollen cells, with rather indistinctly divergent stratification; trichome (2.1–) 4.2–6.3 μ broad, at the apices up to 15 μ broad, with occasional slight constrictions at the joints in normal condition, but with very deep constrictions when old, usually narrowed down at the point of branching; cells usually cylindrical, rarely quadratic, in old trichomes very much narrowed and elongated or much swollen and vacuolated, at the apices of short branches usually rounded or barrel-shaped; heterocysts intercalary and terminal, intercalary heterocysts (3.1–) 5.2–8.4 μ broad, in old filaments with swollen cells up to 11.5 μ broad and 4.2–12.6 μ long, single, sometimes in pairs, usually cylindrical or rectangular, rarely quadratic or flattened, terminal heterocysts formed at the apices of some of the short branches, spherical or subspherical, usually broader than the trichome.

On brick walls among other algae, Hanwella, Ceylon (Bharadwaja, *loc. cit.*).

#### Var. **tenuis** Bharadwaja

*loc. cit.*, 173, 1934.

Filaments 6.3–11.5 (–14.7) μ broad; sheath 2.1–3.5 (–4.2) μ thick; trichome 2.1–4.5 (–5.2) μ broad; heterocysts intercalary 3.1–5.2 μ broad, 3.1–12.6 μ long, terminal heterocysts absent.

On soil and rocks, intermingled with other Myxophyceae, Railway embankment near Bentotte, Ceylon (Bharadwaja, *loc. cit.*).

### 35. **Scytonema bewsii** Fritsch et Rich

Trans. roy. Soc. S. Afr., 11: 364, fig. 23, 1924; Geitler, Kryptogamenflora, 778, fig. 499, 1932.

Pl. 92, Fig. 2

Filaments intermingled with other algae, well branched, 13–19 μ broad; false branches geminate, mostly abutting on one another; sheath thick, colourless when young, later yellowish brown, lamellation parallel, seldom divergent;

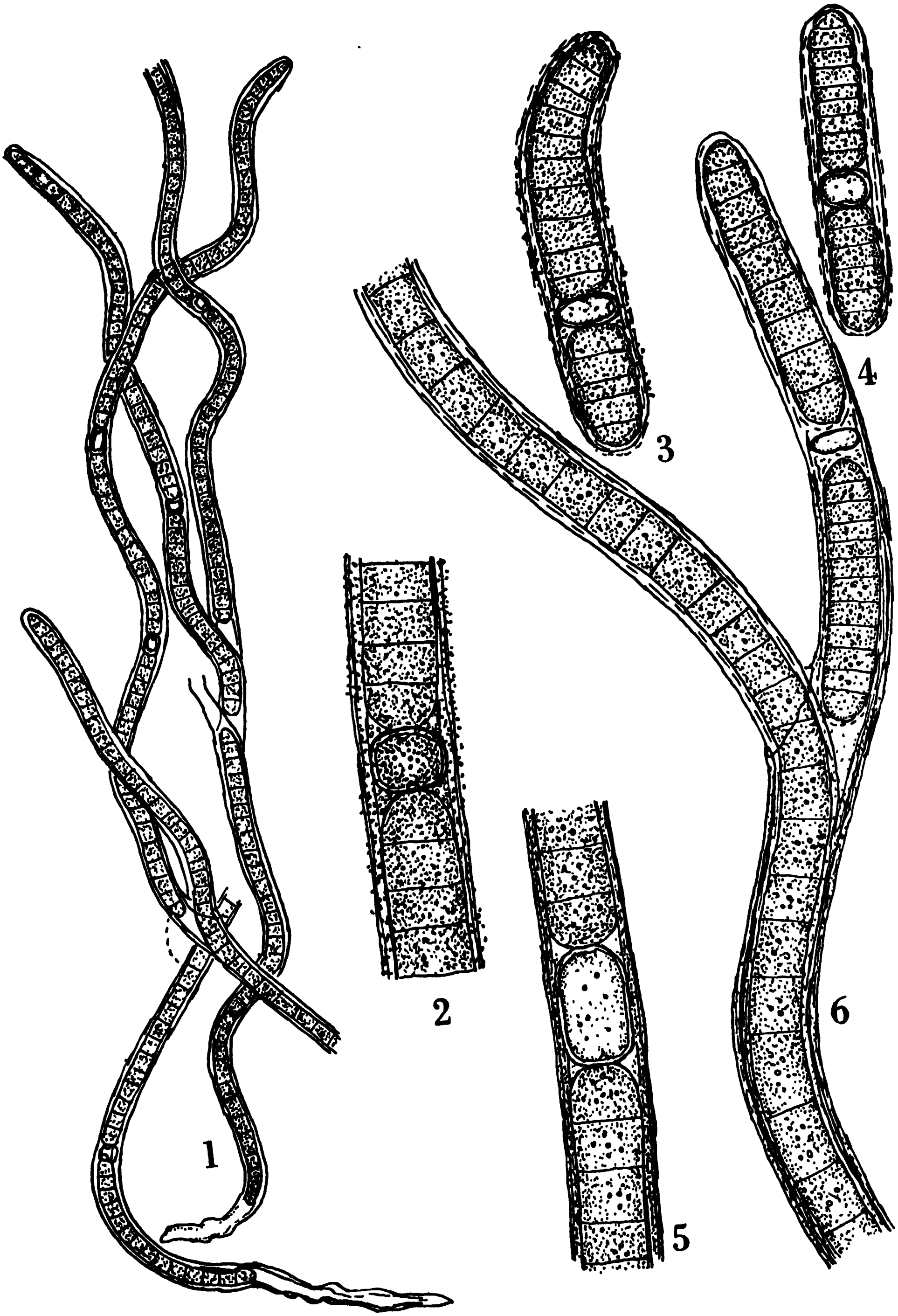

PLATE 96, Figs. 1–6.
*Scytonema pseudopunctatum* Skuja (after Skuja); 3, 4. pseudohormogonia.

cells 3.5–6 μ broad, long-cylindrical, not constricted at the cross-walls, broadened at the apices, the sheath often enveloping the apex, cells discoid at the apex; heterocysts 5–7 μ broad and 16–19 μ long.

On mud settled down on rocks near dam at Latif dam near Benaras (Rao, C. B., 1937b, 356).

Rao's Indian alga is slightly different. -- Filament 10–16 (–19) μ broad; sheath up to 4.9 μ with divergent lamellation; trichomes (3.2–) 4.8–7 μ broad, at the growing apices 10 μ broad; cells 11–23 μ long, at the apices 3.5–4.8 μ long; heterocysts 6.6–10 μ broad and 6.6–16.5 μ long.

### 36. **Scytonema malaviyaensis** Bharadwaja

*Scytonema Malaviyaensis* sp. nov., Rev. algol. Paris, 3: 223, pl. 14, 1930.

Stratum thick, felt-like, spongy, bluish green; sheath firm, at first thin, hyaline or slightly yellow, but later thick, lamellated and yellowish brown, brown to dark brown, 1.4 μ thick in young filaments and 2.8–4 μ thick in old ones; filaments flexuous, interwoven, young ones 8–10 μ broad and in old ones 16.8–20.2 μ broad, 1–4 mm in length; trichomes bluish green or sometimes in colour, mature ones slightly constricted at the joints, simple but occasionally with false branches, false branches only geminate, 6.5–8.5 μ broad in young trichomes and in old trichomes 14–16 μ broad, septa generally very distinct; heterocysts absent in young filaments but present in old ones, median or intercalary, yellow, quadratic, 9.8–15.4 μ broad and 11.2–15.4 μ long; hormogones short, of many cells, or sometimes of only one or two cells, commonly produced by the formation of biconcave intercellular discs, perennating by remaining dormant inside the parent sheaths and secreting new hyaline sheaths on emerging with the recurrence of favourable conditions.

On the barks of trees, Benaras (Bharadwaja, *loc. cit.*).

Frémy (A propos *Scytonema Malaviyaense* Bharadwaja, Rev. algol., Paris, 4(1): 86–87, 1931/32) doubts the distinctness of this species (Pl. 86, fig. 1).

### 37. **Scytonema mirabile** (Dillw.) Born.

Nosto. hétéroc. du Syst. Alg. de C. A. Agargh, Bull. Soc. bot. Fr., 36: 155, 1889; Forti in De Toni, Sylloge Algarum, 5: 517, 1907; Frémy, Myxo. d'Afr. équat. franc., 319, fig. 269, 1929; Geitler, Kryptogamenflora, 775, figs. 497, 498, 1932; Frémy, Cyano. cotes d'Eur., 171, pl. 54, fig. 1, 1933.

= *Scytonema figuratum* Ag., Syst. Alg., 38, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 101, 1887.

Pl. 91, Fig. 3

Thallus expanded spongy, tomentose, brownish black, blackish green, or seldom more or less blue-green; filaments tortuous, intricate, (13–) 15–21 μ

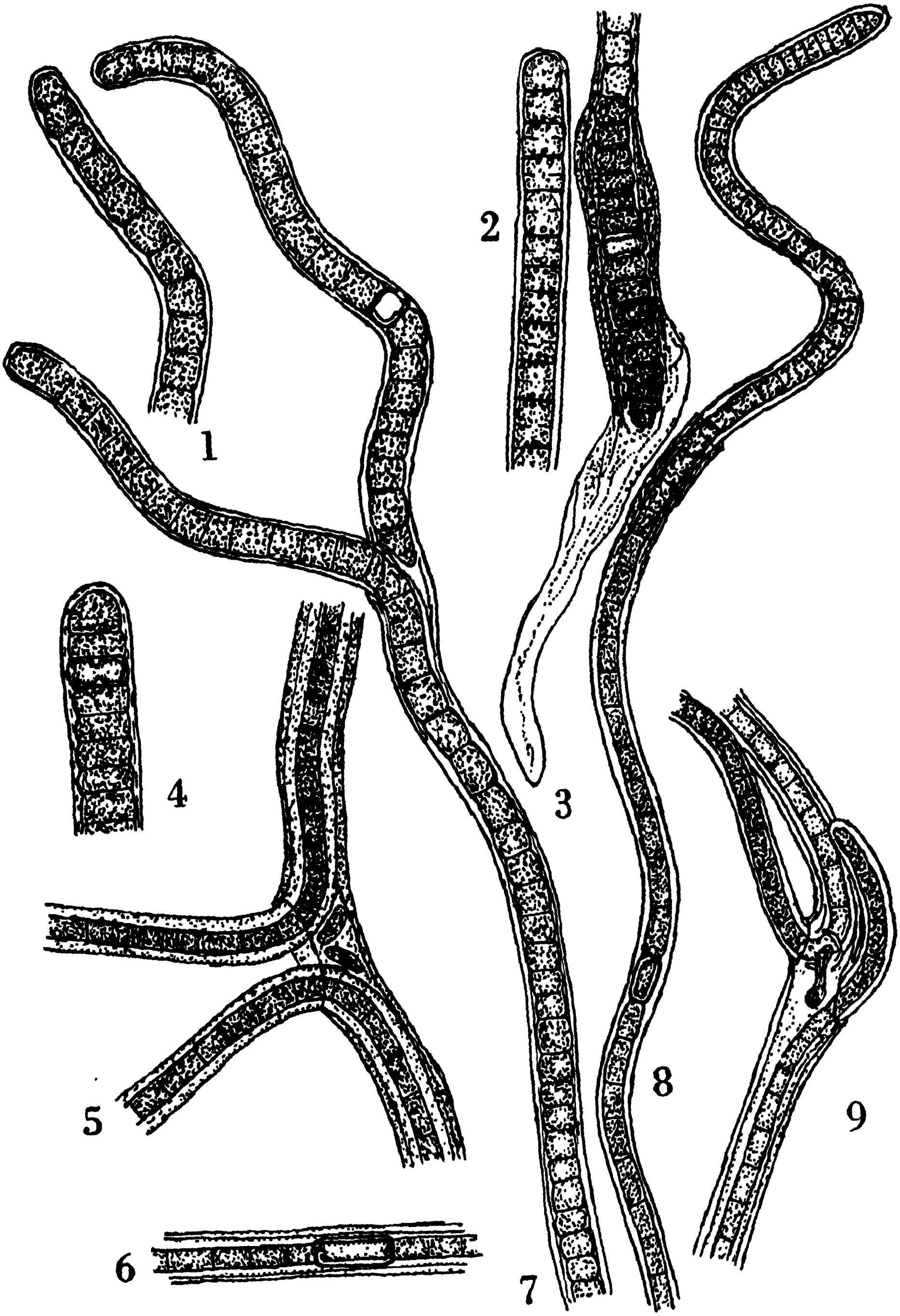

PLATE 97, Figs. 1–9.
*Scytonema burmanicum* Skuja (after Skuja); 3. Shows the formation of pseudohormogonia.

broad, 2–12 mm (rarely 1 cm) long, mostly false-branched; sheath lamellated with slightly divergent lamellation, yellowish brown, sometimes outside colourless or slightly gelatinous; trichome 6–12 μ broad, yellow to blue-green or olive-green; cells cylindrical, at the ends discoid or more or less barrel-shaped; heterocysts nearly quadratic or longer than broad, brownish.

On soil, road slimes, tree trunks, paddy-fields, on moist walls and on moist banks of reservoirs. — Bombay, Igatpuri, Panchgani, Mahabaleshwar (Schmidle, 1900b, 161), Calcutta (Bruhl and Biswas, 1923, 14; Biswas, 1925, 8; Banerji, 1938, 97), Berkuda island (Biswas, 1924, 364), Mir Alam and Husain Sagar Tanks, Hyderabad (Ghousuddin, 1936, 150), Benaras (Rao, C. B., 1937b, 356), Namdur in Andhra Pradesh (Rao, C. B., 1938a, 87) and Shembaganur in Madras State (Frémy, 1942, 22) in India; Henaratgodha and Hanwella in Ceylon (West and West, 1902, 202; Bharadwaja, 1934, 170); Rangoon (Ghose, 1927e, 83; Skuja, 1949, 37) and Maymyo island in Burma (Ghose, 1927d, 255).

Bharadwaja (The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 170, 1934) describes a form.—

Filaments 7.8–8.4 μ broad, when old up to 10.5 μ; sheath 1.5–1.8 μ thick, in older filaments up to 2.1 μ thick; with divergent stratification; trichomes 4.4–5.2 μ broad, when old and healthy up to 6.3 μ broad, and when old and unhealthy narrowed down to 3.2 μ; heterocysts 4.4–5.2 μ broad and 2.5–9.4 μ long.— On stoneworks near Hanwella, Ceylon.

### f. **minor** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 170, figs. 5B-C, 1934.

Pl. 98, Fig. 1

Filaments 8.4 μ broad, occasionally up to 9.4 μ thick sometimes as narrow as 6.6 μ, when old up to 12.7 μ; sheath up to 1.5 μ sometimes up to 1.7 μ rarely up to 2.1 μ, in old filaments up to 3.5 μ thick, hyaline, rarely coloured yellow, indistinct parallel stratification, unstained by chlor-zinc-iodide, when old pigmented yellow brown with distinct parallel layers; trichomes 4.2–5.2 μ broad, sometimes up to 5.7 μ broad; heterocysts cylindrical, more or less convex end walls, 4.2–5.2 μ broad, sometimes up to 5.7 μ broad, up to 14.7 μ long.

In a drying pool, Elliot Beach, Madras (Bharadwaja, *loc. cit.*).

### 38. **Scytonema crustaceum** Ag. ex Born. et Flah.

Agardh, Systema Algar., 39, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 106, 1887; Forti in De Toni, Sylloge Algarum, 5: 525, 1907; Frémy, Myxo. d'Afr. équat. franc., 324, fig. 271, 1929; Geitler, Kryptogamenflora, 782, fig. 504, 1a and 1b, 1932.

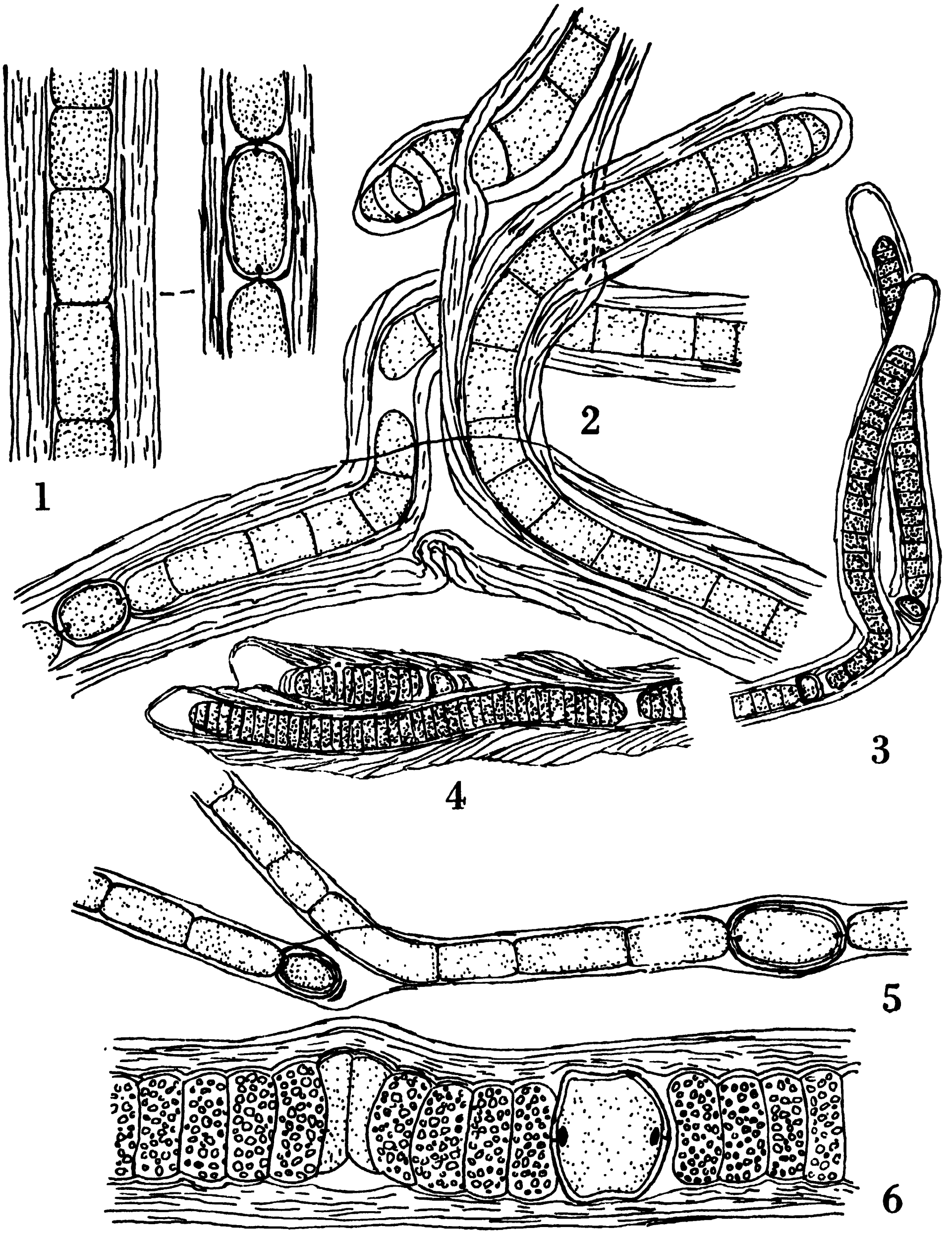

PLATE 98, Figs. 1–6.

1. *Scytonema mirabile* f. *minor* Bharadw ; 2. *Scytonema mirabile* (Dillwyn) Born. ; 3. *Tolypothrix distorta* v. *samoensis* Wille ; 4. *T. magna* Bharadw. ; 5. *T. nodosa* Bharadw. ; 6. *Scytonema millei* forma (all after Bharadwaja).

= *Petalonema crustaceum* (Ag.) Kirchner in Engler and Prantl, Natürlichen Pflanzenfam., I, 1a: 79, 1900.

Pl. 88, Fig. 4 & Pl. 99, Fig. 1

Thallus cushion-like, black, 0.5–2 mm high; filaments 15–30 μ broad, short, erect, aggregated, often slightly thickened and decumbent; false branches numerous ascending, short, in pairs united at the base and free above; sheath gelatinous, yellowish brown, lamellated, lamellae divergent; trichomes 6–8 μ broad, blue-green; cells subquadrate or depressed; heterocysts oblong.

On damp soil, Cherrapunji, Assam (Biswas, 1934, 15).

39. **Scytonema myochrous** (Dillw.) Ag. ex Born. et Flah.

Agardh, Disp. Alg. Sueciae, 38, 1812; Bornet and Flahault, Revision des Nostocacées hétérocystées, 104, 1887; Forti in De Toni, Sylloge Algarum, 5: 521, 1907; Frémy, Myxo. d'Afr. équat. franc., 321, fig. 269, 1929; Geitler, Kryptogamenflora, 780, figs. 49, 501, 502, 1932; Frémy, Cyano. cotes d'Eur., 171, pl. 54, fig. 2, 1933.

= *Scytonema chlorophaeum* Kützing, Phyc. gene., 216, 1843 (incl. f. *tenuis* Mart.).

= *Scytonema turfosa* Kützing, Phyc. gene., 216, pl. 6, fig. 1 (15–18), 1843.

= *Scytonema tomentosum* Kützing, Phyc. gene., 217, 1843.

= *Scytonema gracile* Kützing, Diagnosen und Bemerkungen zu neuen oder kritischen Algen, Bot. Ztg., 5: 196, 1847.

Pl. 90, Fig. 3 & Pl. 99, Fig. 2

Thallus woolly, widely expanded, spongy tomentose, brownish black or blackish green; filaments tortuous, intricate, 2–15 mm long, (15–) 18–36 (–40) μ broad; sheath lamellated, yellowish brown, lamellae divergent; trichomes 6–12 μ broad, yellowish green, cells elongate, cylindrical below and discoid above; heterocysts subquadrate or longer than broad, brown; spores globose, yellowish brown.

On moist soil, on trees and in stagnant waters. — Calcutta (Martens, 1870a, 11; Prain, 1905, 335), between Silligoree and Titatya in Bengal (Martens, 1870a, 12), N. India (Turner, 1892, 14), Shembaganur (Frémy, 1927, 46/47; 1942, 22) and on moist soil, Tirupati ( ! ) in India; Colombo (Zanardini, 1872, 157) and Ferguson's collection from Ceylon (Murray, 1887, 43); Rangoon (Zeller, 1873b, 182; Theobald, 1883, 22; Ghose, 1926, 250; 1927e, 82; Skuja, 1949, 37) and on the Irrawady flats and at Palay-kweng in Burma (Zeller, 1873b, 182).

The filaments in Frémy's collections were 15 μ broad.

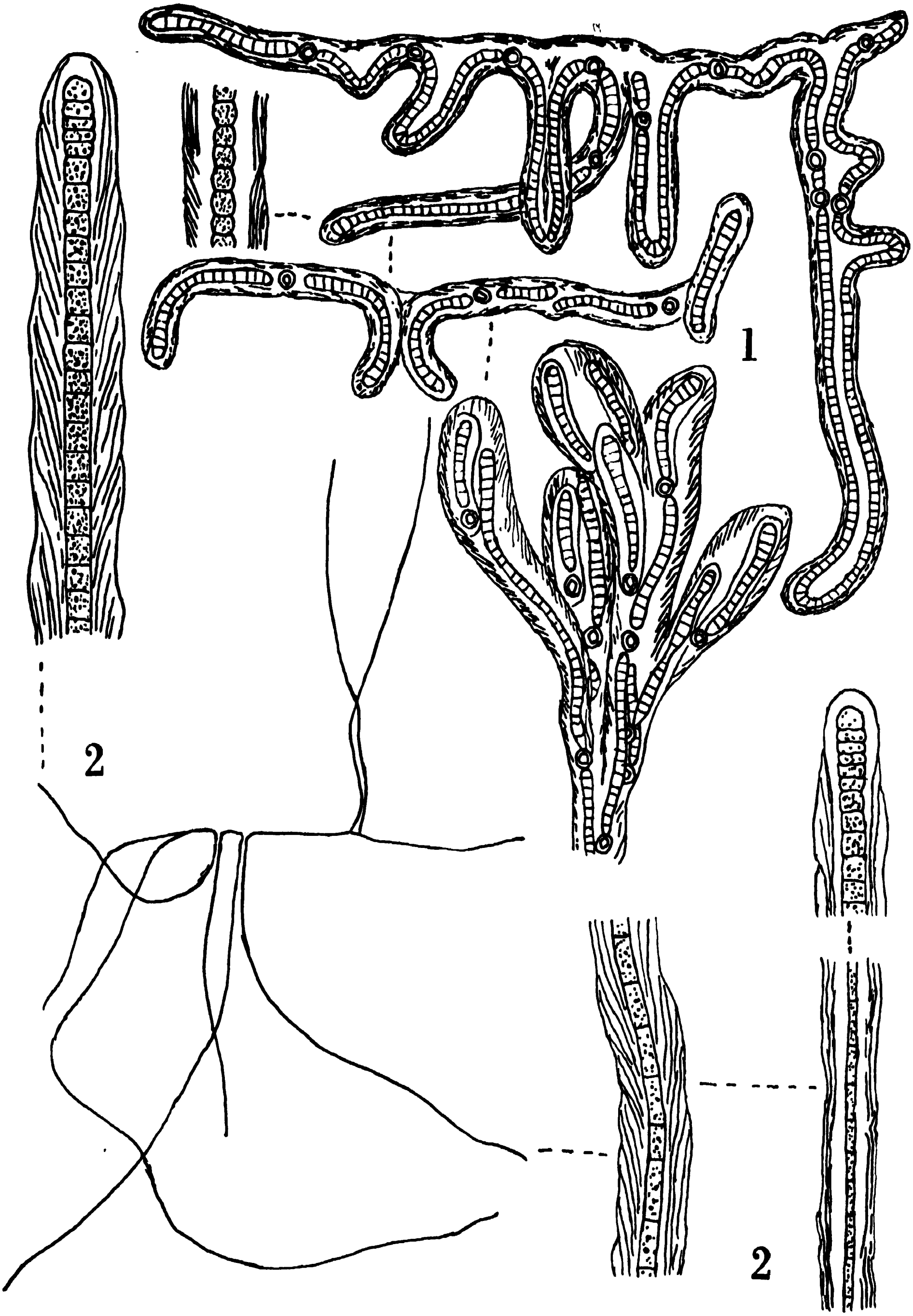

PLATE 99, Figs. 1–2.
1. *Scytonema crustaceum* Ag.; 2. *S. myochrous* (Dillw.) Ag. (all after Kossinskaja).

Bharadwaja (1934, 174) described a form of *S. myochrous* growing on wet rocks below Gundar Waterfalls in S. India. — Filaments 22.5–25.6 (–31.5) μ broad; false branches up to 11.5–18.9 (–23.1) μ broad; sheath 6.3–7.3 (–13.1) μ thick; trichomes (7.3–) 9.9–11 μ broad, when old down to 5.2 μ broad; heterocysts 7.3–14.7 μ broad and 9.4–14.7 μ long. This form differs from the type in the very short cells and the formation of geminate branches by loops as also in the occasional presence of slight constrictions at the cross-walls. This form has again been collected on wet rocks near a waterfall at Kodaikanal.

### 40. **Scytonema crassum** Nägeli ex Born. et Flah.

Nägeli, in Kützing, Species Algarum, 894, 1849; Tab. Phycologicae, 2: 7, pl. 26, fig. 4, 1850–52; Bornet and Flahault, Revision des Nostocacées hétérocystées, 109, 1887; Forti in De Toni, Sylloge Algarum, 5: 527, 1907; Geitler, Kryptogamenflora, 782, 1932.

Thallus an expanding cushion, spongy tomentose, blackish-green; filaments contorted at the base, flexuous, erect, 1 mm long, 27–45 μ broad; false branches erect-ascending; sheath ocreate, much lamellated, lamellae dilated, inner layers yellowish, middle ones brownish, outer ones colourless; trichome 9–15 μ broad, greenish brown; cells subquadrate or oblong; heterocysts brownish, subquadrate or globose.

Ceylon (Grunow *see* Bornet and Flahault, *loc. cit.*).

### **Scytonema zelleriamum** Bruhl et Biswas

Indian Bark Algae, J. Dept. Sci., Calcutta Univ., 5: 16, pl. 5, figs. 20a-d, 1923.

= *Scytonema aureum* Meneghini in Zeller in Journ. Asiatic Soc. Bengal, 42: p. 181, 1873b; *non alibi.*

Thallus extensive about 1 mm thick, densely felty, from brown to nearly black; filaments long and flexible, false branches single or in pairs, slender, somewhat thinning out towards the apex, sometimes recurved; sheath firm, 3–5 μ thick, consisting of 2–5 lamellae, brown; trichomes 10–20 μ thick, not constricted at the joints, bluish green with a yellowish tint; cells about as long as wide, or usually shorter than long; contents uniformly granular; heterocysts distant from the base of the branches, 15–20 μ long, square or oblong, yellowish.

On rocks, mud banks of rivers, barks of trees, mud walls, on damp soil. — Punkabaree, Calcutta, Hooghly river near Calcutta (Martens, 1870a, 11; Martens, 1870b, 259; Prain, 1905, 335; Bruhl and Biswas, 1923, 16); Choung-menah hills, Tonkyeghat in Karen, elephant point between Rangoon and Sanjiwa, Kayengmathay streams, and Rangoon in Burma (Martens, 1871b, 463; Zeller, 1873b, 181; Theobald, 1883, 181; Ghose, 1926, 251; Ghose, 1927e, 82).

Zeller has described a number of specimens as *Scytonema aureum* Meneghini. Meneghini's specimens were considered to be *Tolypothrix* (*T. aureus* (Menegh.) Borzi) by Borzi. Bruhl and Biswas have re-examined the specimens of Zeller and Kurz and found them to be *Scytonema* and not *Tolypothrix*. Hence they created this species to receive Zeller's specimens.

## SPECIES INQUIRENDAE

### **Scytonema rhizophorae** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42: 183, 1873; Hedwigia, 12: 173, 1873; Forti in De Toni, Sylloge Algarum, 5: 534, 1907.

Caespitose, pale olivaceous, when dried bluish black, spongiose about 1 mm diam.; filaments fasciculate, flexuous, brownish, sparsely false branched, with sheath about 7.5–10 µ broad, apex attenuated; trichome pale bluish, cells as long as or ⅓ as long as broad; sheath close, at the base and the acuminate apex hyaline; heterocysts oblong.

On tree trunks in Mangrove swamp at Elephant Point, Pegu (Zeller, *loc. cit.*).

### **Scytonema violascens** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42: 183, 1873; Hedwigia, 12: 173, 1873; Forti in De Toni, Sylloge Algarum, 5: 534, 1907.

Caespitose, erect, 7–10 mm high, pale violet; filaments at the base 15–22 µ diam.; trichome 17–20 µ broad, fasciculate, sparsely branched, false branches geminate, adpressed, intricate, elongate, thin, whip-like, variously coloured, violet bluish, or brownish yellow, at the apex 9 µ diam., attenuated, pallidioribus or hyaline; cells ½ as short as broad; sheath close, hirtis, hyaline; yellowish.

On clayey soil, in Choungmenah stream, Yoma Valley, Pegu (Zeller, *loc. cit.*; Theobald, 1883, 22).

### **Scytonema olivaceum** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42: 183, 1873; Hedwigia, 12: 173, 1873; Forti in De Toni, Sylloge Algarum, 5: 534, 1907.

Thallus caespitose, 5–8 mm high, olivaceous; filaments slightly flexuous, rigid, 15–19 µ broad; trichome about 12.5 µ broad; cells distinct, as long as broad or ½ shorter than broad; false branches divaricate, geminate, filaments not narrow; sheath brown, smooth.

In cracks in the sandstones in the Zaymanichoung, Pegu, Burma (Zeller, 1873a, 183; 1873b, 173; Theobald, 1883, 22).

### **Scytonema parvulum** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42: 183, 1873; Hedwigia, 12: 173, 1873; Forti in De Toni, Sylloge Algarum, 5: 535, 1907.

Thallus thin, tomentose, brownish; filaments short, attenuated, at the base 6 μ diam., and at the apex 4.5 μ broad; trichome green, 3.2 μ broad, with distinct cells at the base; cells subquadrate to longer than broad; septa indistinct; sheath brownish.

On sandstones in southern Yomah, Pegu (Zeller, 1873a, 183; 1873b, 173; Theobald, 1883, 22).

### **Scytonema maculiforme** Schmidle

Einige neue von Prof. Dr. Hansgirg in Vorderindien gesammelte Süsswasseralgen, Allg. bot. Zeitschr., 78, 1900a; Ueber einige von Professor Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 184, 1900b.

Thallus maculiform, rotund, 1–3 mm diam., black; filaments convolute and intricate, horizontally expanded in all directions, 8–10 μ broad, apex curved erect; false branches short up to 200 μ long, geminate, erect, vertically disposed in all directions; sheath yellowish, thin, adhering, fragile, at the apices of false branches generally thicker, brownish black, lamellae visible with difficulty; cells subquadrate, longer or shorter than broad; heterocysts gregarious, hyaline, shape and size variable.

On leaves, Mahabaleshwar near Bombay (Schmidle, *loc. cit.*).

### **Scytonema granulatum** Martens

A fifth list of Bengal algae, Proc. Asiatic Soc. Bengal, 40: 172, 1871a. -- On muddy banks, Salt lakes, Calcutta (Martens, 1871a, 172; Prain, 1905, 172; Biswas, 1926, 28).

### **Scytonema aerugineo-cinereum** Kütz

Phyc. gene., 214, 1843. — On walls of buildings, Calcutta (Martens, 1871a, 171; Prain, 1905, 335).

### **Scytonema subclavatum** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42: 183, 1873; Hedwigia, 12: 173, 1873; Forti in De Toni, Sylloge Algarum, 5: 534, 1907. — On old brickwork in Henzadah, Burma (Zeller, 1873a, 183; 1873b, 173; Theobald, 1883, 22).

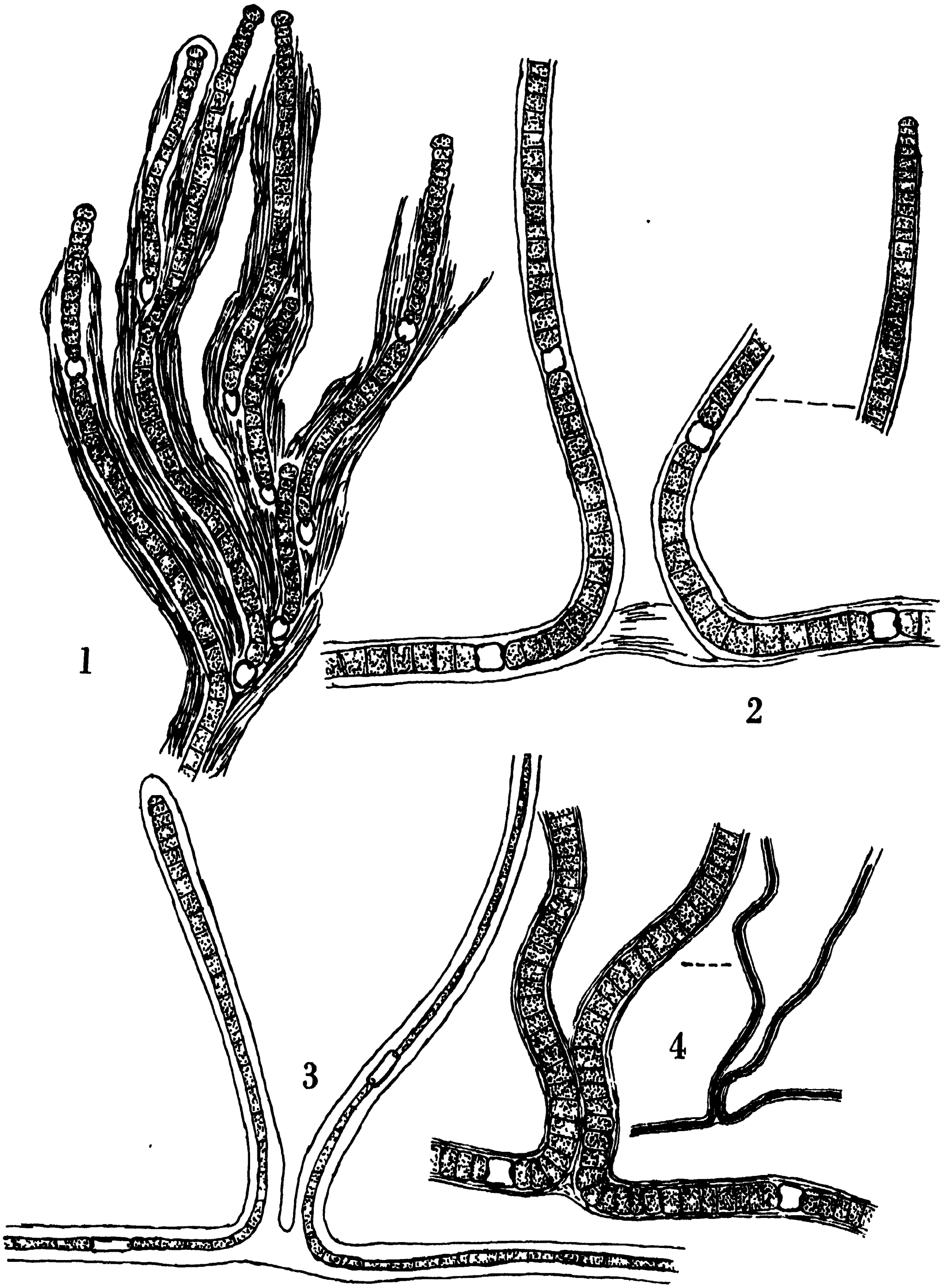

PLATE 100, Figs. 1–4.

1. *Tolypothrix foreauii* Frémy; 2. *Scytonema rivulare* Borzi; 3. *S. frémyii* nom. nov.; 4. *S. javanicum* (Kütz.) Born. (all after Frémy).

## TOLYPOTHRIX Kützing

Phyc. gene., 227, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 118, 1887.

Filaments with a generally firm, thin or thick sheath with a single trichome in each sheath; false branched, mostly free, prostrate or erect; false branches single mostly subtending a heterocyst, occasionally geminate as in *Scytonema*; hormogonia formed from the tips; trichome with apical growth, apices often broader with shorter cells; spores known in some species.

Type species: *T. distorta* Kütz.

### KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Associated with animals | 1. *T. lophopodellophila* (p. 494) |
| 1. | Not associated with animals | 2 |
| 2. | Sheath thin | 3 |
| 2. | Sheath thick | 13 |
| 3. | Aquatic | 4 |
| 3. | Terrestrial | 7 |
| 4. | Cells as long as or longer than broad | 5 |
| 4. | Cells shorter | 6 |
| 5. | Trichomes 4.2–5.2 (–6.3) μ broad | 2. *T. nodosa* (p. 494) |
| 5. | Trichomes 5–8 μ broad | 3. *T. tenuis* (p. 494) |
| 6. | Filaments up to 17 μ broad | 4. *T. distorta* (p. 495) |
| 6. | Filaments above 20 μ broad | 5. *T. robusta* (p. 499) |
| 7. | Cells shorter than broad | 8 |
| 7. | Cells longer than broad | 6. *T. phyllophila* (p. 499) |
| 8. | Filaments 5–7 μ broad | 9 |
| 8. | Filaments broader | 10 |
| 9. | Trichomes constricted | 7. *T. bouteillei* (p. 499) |
| 9. | Trichomes unconstricted | 8. *T. fragilis* (p. 500) |
| 10. | Filaments 8–12 μ broad | 11 |
| 10. | Filaments broader | 12 |
| 11. | Filaments united by the sheath, erect, sheath rough | 9. *T. ceylonica* (p. 500) |
| 11. | Filaments free | 10. *T. campylonemoides* (p. 502) |
| 12. | Cells as long as broad | 11. *T. byssoidea* (p. 502) |
| 12. | Cells longer | 12. *T. rechingeri* (p. 503) |
| 13. | Aquatic | 17 |
| 13. | Terrestrial | 14 |
| 14. | Sheath not lamellated | 15 |
| 14. | Sheath lamellated | 16 |
| 15. | Filaments 14–18 μ broad | 13. *T. conglutinata* (p. 503) |
| 15. | Filaments 23.1–35.7 μ broad | 14. *T. magna* (p. 503) |
| 16. | Filaments 14.5–18 μ broad | 15. *T. arenophila* (p. 504) |
| 16. | Filaments 25–27 μ broad | 16. *T. crassa* (p. 504) |
| 17. | Filaments 14–21 μ broad, sheath very thick, ocreate | 17. *T. foreaui* (p. 504) |
| 17. | Filaments 10–15 μ broad, sheath not so thick or ocreate | 18. *T. limbata* (p. 505) |

### 1. **Tolypothrix lophopodellophila** West

Descriptions of the new species of Algae associated with freshwater Polyzoa with notes by Dr. N. Annandale, J. asiatic Soc. Bengal, n. s., 7: 83, 1911.

Thallus brownish, floccose; trichomes false, branched, densely intricate; cells distinct, sometimes indistinct, quadrate to somewhat longer than broad; sheath thick, more or less irregular at the margins; heterocysts 1–3 at the base of pseudobranches, oblong to round, ¼–2 as long as broad, broader than the trichome.

Forming irregular gelatinous masses on stems submerged at the edge of Igatpuri lake, Bombay state associated with *Lophopodella carteri* (West, *loc. cit.*).

### 2. **Tolypothrix nodosa** Bharadw.

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 175, fig. 7c, 1934.

Pl. 98, Fig. 5

Stratum thick, mucilaginous, blue-green to yellow-brown; filaments irregularly bent, densely entangled, 5.2–7.3 (–8.4) μ broad; false branches few, geminate and single, single branches by the side of dead cells, one pored heterocysts or dead-cells adjoining such heterocysts; sheath firm, thin, occasionally slightly thickened opposite the septa, hyaline, often bulged out at the point of branching; trichomes constricted at the joints, septa indistinct; cells cylindrical, up to 5 times as long as broad, sometimes quadratic; heterocysts intercalary and terminal (basal), single, ellipsoidal, rarely cylindrical with convex walls, when mature much wider than the trichome, 4.2–9.4 μ broad and 7.3–16.8 (–23) μ long.

In stagnant ponds.—Benaras (Bharadwaja, *loc. cit.*; Rao, C. B., 1937b, 353) and Namdur and Polamur in Andhra state (Rao, C. B., 1938a, 86).

### 3. **Tolypothrix tenuis** (Kütz.) Johs. Schmidt em.

Bot. Tidsskr., 22: 383, 1899; Lemmermann, Kryptogamenflora der Mark Brandenburg, 3: 217, 1910; Frémy, Myxo. d'Afr. équat. franc., 286, fig. 251, 1929; Frémy, Cyano. cotes d'Eur., 168, pl. 53, fig. 2, 1933.

= *T. tenuis* Kütz. Phyc. gene., 228, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 122, 1887 (incl. all forms).

= *T. muscicola* Kütz. Phyc. gene., 227, 1843.

= *T. lanata* Wartmann in Rabenhorst, Fl. Eur. Alg., 2: 277, 1865. *non* Kützing (incl. all forms).

= *T. inflata* Ghose, On some Myxophyceae from Maymyo. J. Burma Res. Soc., 17: 254, pl. 4, fig. 4, 1927d.

Pl. 102, Fig. 4

Thallus caespitose or cushion-like, blue-green or brown; filaments (4–) 6–17 (–18) μ broad, up to 2 cm long, repeatedly branched; sheath thin, close to the trichome, at first colourless, later yellowish brown, often lamellated; cells (4–) 5–13 μ broad, quadrate or longer than broad, blue-green, slightly or not constricted at the cross-walls; heterocysts cylindrical, rounded or discoid, 6–14 μ broad and 2.3–6 μ long colourless or yellowish, solitary or 2 to 5 in a row.

Freshwater algae in N. India (Turner, 1892, 14); on walls and soil, Gandevi near Bombay (Dixit, 1936, 100), in a water reservoir, Benaras (Rao, C. B., 1937b, 354), in a pond, Veli, Travancore (Parukutty, 1940, 118) and Delhi (Rao, C. S., 1940, 127); in a pool in a glen near Bandarawella, in tank Madukotaikulam near Trincomalie and in a tank between Anuradhapuram and Kandy in Ceylon (West and West, 1902, 202; Crow, 1923b, 143; Bharadwaja, 1934a, 176); in a pond, Maymyo island in Burma (Ghose, 1927d).

*T. lanata* and *T. tenuis* are differentiated essentially on the basis of the breadth of the filaments (see Bornet and Flahault, 1887, p. 118). Schmidt, Johs., has however shown that the presence of variation in *T. lanata* makes a clear demarcation of the two species difficult and has amended the older of the two species, *T. tenuis* to include *T. lanata* and a few other related species. Geitler (1932, p. 716) thinks that *T. inflata* Ghose is not very much different from either of the two species and include the same in *T. tenuis*. Many forms and varieties of *T. lanata* and *T. tenuis* are known from India based on both the dimensions of the filaments and on the absence of the heterocysts in chains etc. These varieties have not been named at all. It is very difficult to separate varieties and forms.

Kossinskaja in Elenkin (1938, p. 955) distinguishes five forms based on the different taxa included in *T. tenuis* (Kütz.) Schmidt, Johs. (f. *aegagrophila*, f. *tenuis*, f. *terrestris*, f. *polymorha*, f. *lanata*). Nielson and Madson (Amer. Midl. Nat., 55: 197–198, 1956) keep *T. tenuis* and *T. lanata* distinct.

### 4. **Tolypothrix distorta** Kützing ex Born. et Flah.

Kützing, Phyc. gene., 228, 1843; Bornet and Flahault, Revision des Nostocacées hétérocystées, 119, 1887; Geitler, Kryptogamenflora, 719, fig. 460, 1932.

Pl. 102, Fig. 1

Thallus caespitose or cushion-like, expanded, blue-green to brownish, sometimes calcium incrusted; filaments richly false-branched, up to 3 cm long, 10–15 μ broad, false branches mostly deeply or sharply erect; sheath thin,

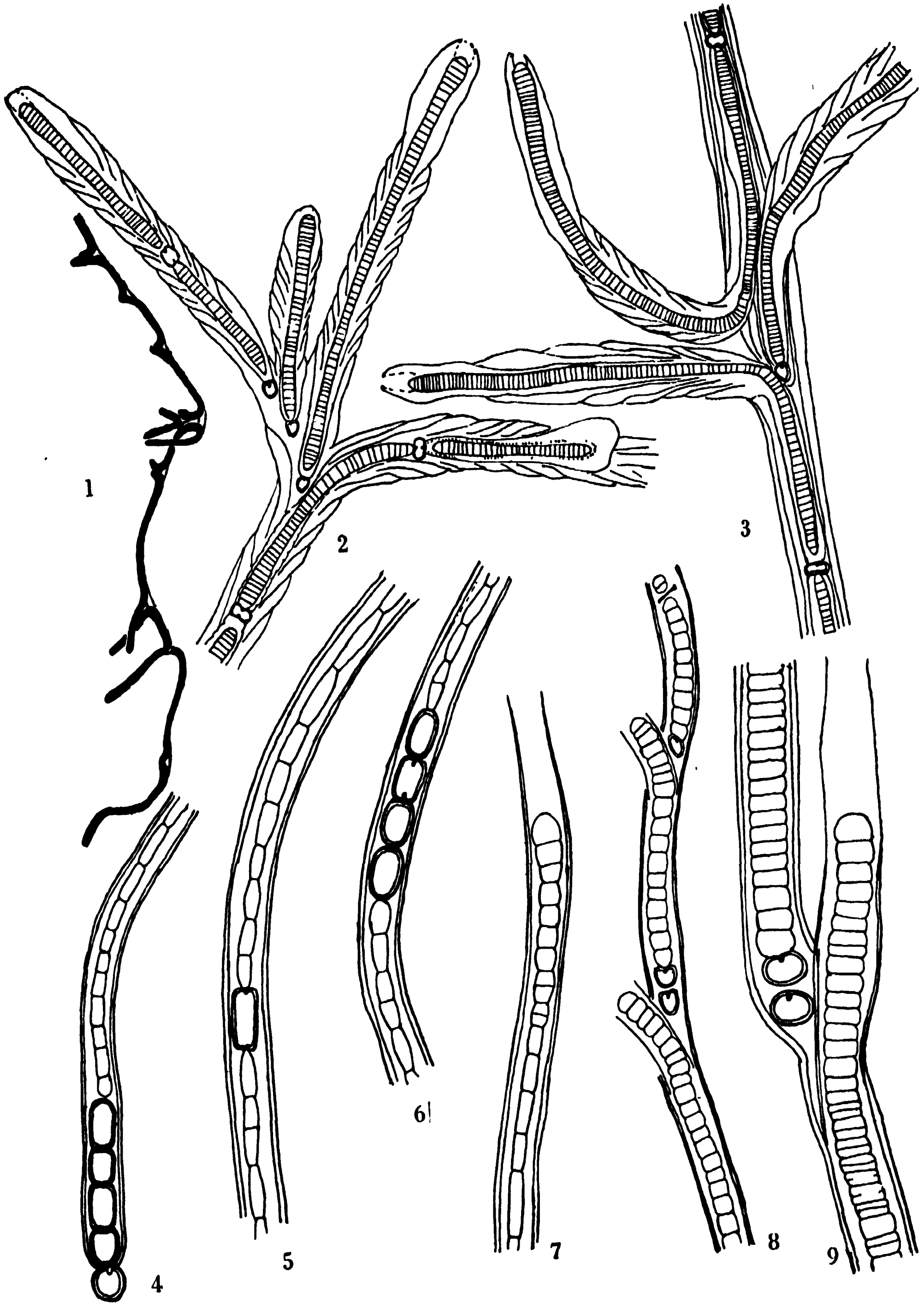

PLATE 101, Figs. 1–9.

1–3. *Petalonema densum* (A. Br.) Migula; 4–7. *Fortiea bossei* (Frémy) comb. nov.; 8. *T. bouteillei* (Bréb. et Desm.) Forti; 9. *T. distorta* v. *penicillata* (Ag.) Lemm. (all orig.).

close to the trichome, at first colourless later brownish; trichomes 9–12 μ broad, slightly torulose, blue-green; cells as long as broad or shorter than broad; heterocysts single or 2–3 nearly spherical to cylindrical.

In stagnant water and in very slow flowing waters, Lahore (Ghose, 1919, 11); on stones in running waters, Crinoline falls, Shillong (Parukutty, 1939, 232); in a tank at Bandra (Gonzalves and Joshi, 1946, 176).

Both the Lahore and the Shillong algae have narrower trichomes (6.6–11 μ broad) and the heterocysts are upto 15 μ long.

### Var. **penicillata** (Ag.) Lemm.

Kryptogamenflora der Mark Brandenburg, 3: 218, 1910; Geitler, Kryptogamenflora, 719, fig. 461, 1932.

= *Tolypothrix penicillata* (Ag.) Thuret, Essai class. Nost., Ann. Sci. nat., 6th ser., Bot., 1: 380, 1875; Bornet and Flahault, Revision des Nostocacées hétérocystées, 123, 1887.

Pl. 101, Fig. 9 & Pl. 102, Fig. 2

Thallus penicillate-caespitose, or cushion-like; filaments many cms long, 8–17 μ broad, repeatedly false-branched; sheath thin, close to the trichome, at first colourless later brown; trichomes 4–13 μ broad, cells as long as broad or shorter or longer than broad; heterocysts single, yellowish, cylindrical, quadratic, spherical.

Ferguson's collection from Ceylon (Murray, 1887, 44); in stagnant ponds in rivulets, Borivli, Santa Cruz, near Bombay (Dixit, 1936, 100); on some rocks in a mountain rivulet, Mamandur near Renigunta, Andhra State ( ! ).

The filaments in the Mamandur collection were broader (13.1–25 μ broad).

### Var. **samoensis** Wille

in Rechinger, Ergebn. Wiss. Forsch. Samoa Insl. VI, Denkschr. Akad. Wiss. Wien, 9: 150, pl. 2, figs. 29–31, 1915.

Pl. 98, Fig. 3

Thallus woolly, cushion-shaped, blue-green or olive-green; filaments 14–28 μ broad; sheath lamellated, colourless or yellowish green; false branches single, seldom geminate, sparse; trichome 10–18 μ broad; cells barrel-shaped, as long as broad or longer, at the ends of branches up to ¼ as long as broad; heterocysts rounded, as long as broad, single.

On moist rocks among Liverworts and Mosses, at Hantana, near Peradiniya, Ceylon (Bharadwaja, 1934a, 175); in a cemented reservoir, Benaras (Rao, C. B., 1937b, 354).

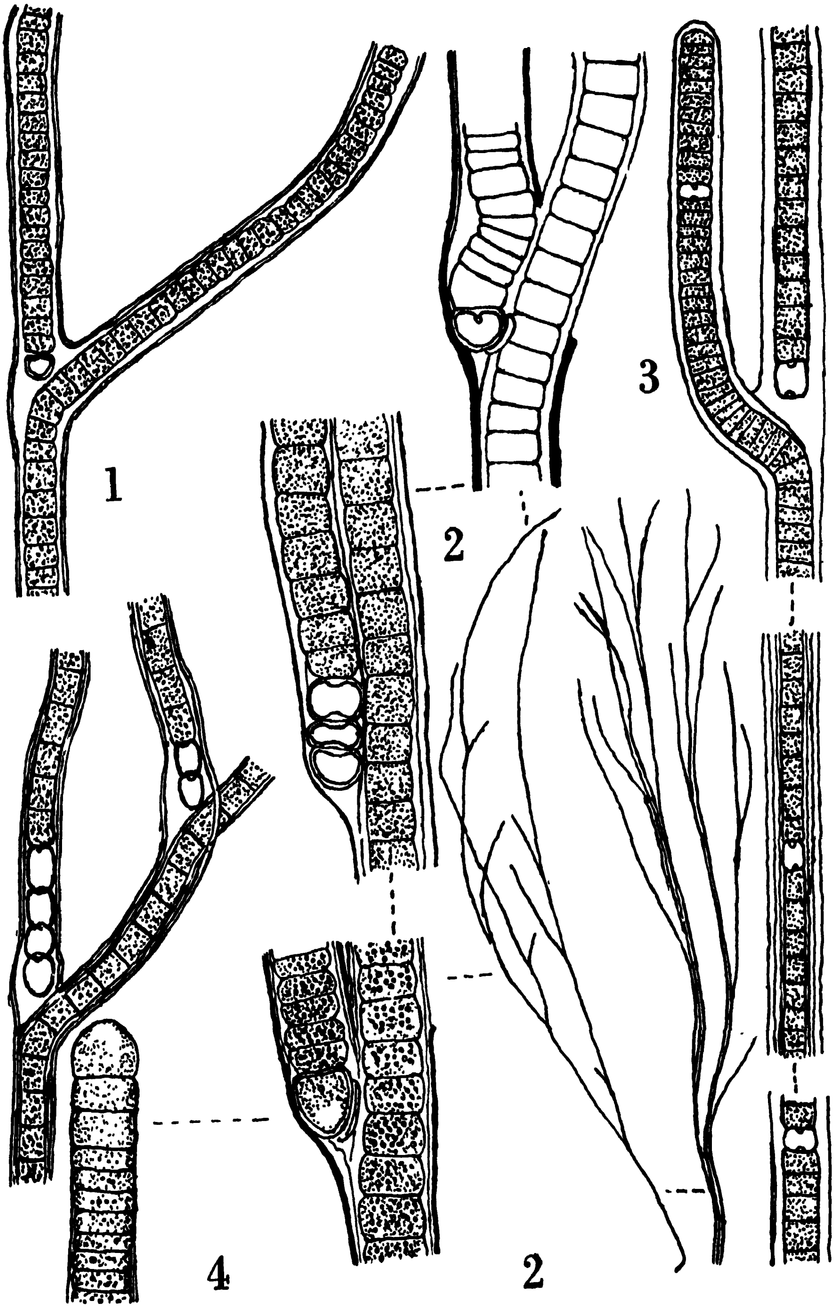

PLATE 102, Figs. 1–4.

1. *Tolypothrix distorta* Kütz. (after Frémy); 2. *T. distorta* v. *penicillata* (Ag.) Lemm. (after Geitler); 3. *T. robusta* Gardner (after Gardner); 4. *T. tenuis* (Kütz.) J. Schmidt. (after Frémy).

Lemmermann (1910, 23 and 219) says that the plant thallus is highly variable in *T. distorta* and that many of the forms of the species are better merged with the type.

### 5. **Tolypothrix robusta** Gardner

Myxophyceae from Porto Rico, Mem. N. Y. bot. Gdn., 7: 87, pl. 20, fig. 49, 1927; Geitler, Kryptogamenflora, 722, fig. 457b, 1932.

Pl. 102, Fig. 3

Filaments 1–2 mm long, 22–30 μ broad, straight, flexuous; trichome 12–18 μ broad, in older parts narrower than in the younger ones, more or less constricted at the cross-walls; cells in older parts as long as broad, in the meristematic region discoid, and 2–4 μ long; heterocysts as long as broad and similar to the vegetative cells; sheath when young colourless and unlamellated, when old colourless to brownish and lamellated.

Type not recorded.

Rao, C. B. (The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 353, 1937b) describes a form.—Filaments 13–17 (–20) μ broad; sheath 2–3.5 μ thick, when old up to 5.5 μ thick; trichome 9–12 μ broad, when old narrowed down to 5.5 μ broad, and in the younger parts up to 15 μ broad; cells 10–12 μ long, when old up to 30 μ long, at the growing apices 4–6 μ long; heterocysts single or in chains of 2–3 (6.6–) 10–13.2 μ broad and 11–42 μ long.—In stagnant ponds and pools, Benaras (Rao, C. B., 1937b, 354); Polamur, Namdur and Narsapur in Andhra State (Rao, C. B., 1938a, 86); Puri and Berhampore in Orissa (Rao, C. B., 1938b, 162).

### 6. **Tolypothrix phyllophila** West et West

Welwitsch's Freshw. Afr. Alg., J. Bot. Lond., 35: 267, 1897; Forti in De Toni, Sylloge Algarum, 5: 553, 1907; Frémy, Myxo. d'Afr. équat. franc., 288, 1929; Geitler, Kryptogamenflora, 734, 1932.

Thallus olive-green or blackish green; filaments densely entangled, somewhat 1 mm long, 12.5–18 μ broad, irregularly false-branched; false branches short, nearly parallel with the main filament; sheath thick, firm, colourless without divergent lamellation; trichome 8.5–10 μ broad; cells 1–1½ as long as broad, in the apical meristem sometimes shorter; heterocysts solitary, basal and intercalary, 8.5–13 μ broad, subquadrate, oblong or subhemispherical.

On the banks of a pond, Peradiniya, Ceylon (West and West).

### 7. **Tolypothrix bouteillei** (Bréb. et Desm.) Forti

in De Toni, Sylloge Algarum, 5: 552, 1907.

= *Hassallia bouteillei* (Bréb. and Desm.) Bornet and Flahault, Revision des Nostocacées hétérocystées, 116, 1887.

= *Tolypothrix bouteillei* (Bréb. et Desm.) Lemmermann, Kryptogamenflora der Mark Brandenburg, 3: 219, 1910; Geitler, Kryptogamenflora, 724, fig. 464, 1932.

Pl. 101, Fig. 8 & Pl. 103, Fig. 5

Thallus circular, caespitose, blackish brown, up to 2 mm high; filaments 1 mm long 5–7 μ broad, false-branched; false branches short, deciduous; sheath thin, close to the trichome, colourless to golden yellow; trichomes 4–5 μ broad, torulose; cells somewhat shorter than broad; heterocysts basal, rarely intercalary, single.

In cultures of paddy-field soil, Dahisar near Bombay (Gonzalves and Gangla, 1949, 54) and on moist soil, Madras ( ! ).

The filaments in the Madras alga are broader (6.8–9.2 μ broad).

Both Forti and Lemmermann have created the present combination in 1907. Lemmermann's Kryptogamenflora was issued in parts and this particular part was issued in September 1907; Forti's Sylloge Algarum is dated May 1907. Hence the later combination is adopted here.

### 8. **Tolypothrix fragilis** (Gardner) Geitler

Kryptogamenflora, 724, fig. 465, 1932.

Pl. 103, Fig. 1

Filaments 5.5–7 μ broad, short, straight, forming a thin thallus; sheath thin colourless, not lamellated, sometimes gelatinized, at the bottom of the branch; trichome 4–5.5 μ broad, not constricted at the cross-walls; cells in the older parts of the trichome as long as broad, at the ends half as long as broad; heterocysts spherical or compressed.

On white-washed walls, Benaras (Rao, C. B., 1937b, 355).

The Indian alga has broader trichomes (4.9–6 μ broad) and heterocysts (6.6–7 μ broad and 4–10 μ long).

### 9. **Tolypothrix ceylcnica** Schmidle

Einige neue von Prof. Dr. Hansgirg in Vorderindien gesammelte Süswasseralgen, Allgm. bot. Zeitschr., 1900, 78, 1900a; Geitler, Kryptogamenflora, 724, 1932.

= *Hassallia ceylonica* Schmidle, Ueber einige von Prof. Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 185, pl. 9, fig. 3, 1900b.

Thallus expanded, green, olive-green or blackish green, thin, soft and fragile; filaments parallel, erect, generally straight or slightly curved, rarely false branched; false branches short, forming an acute angle with heterocysts at the base, 12 μ and at the apices 8 μ diam., up to 200–300 μ long; sheath

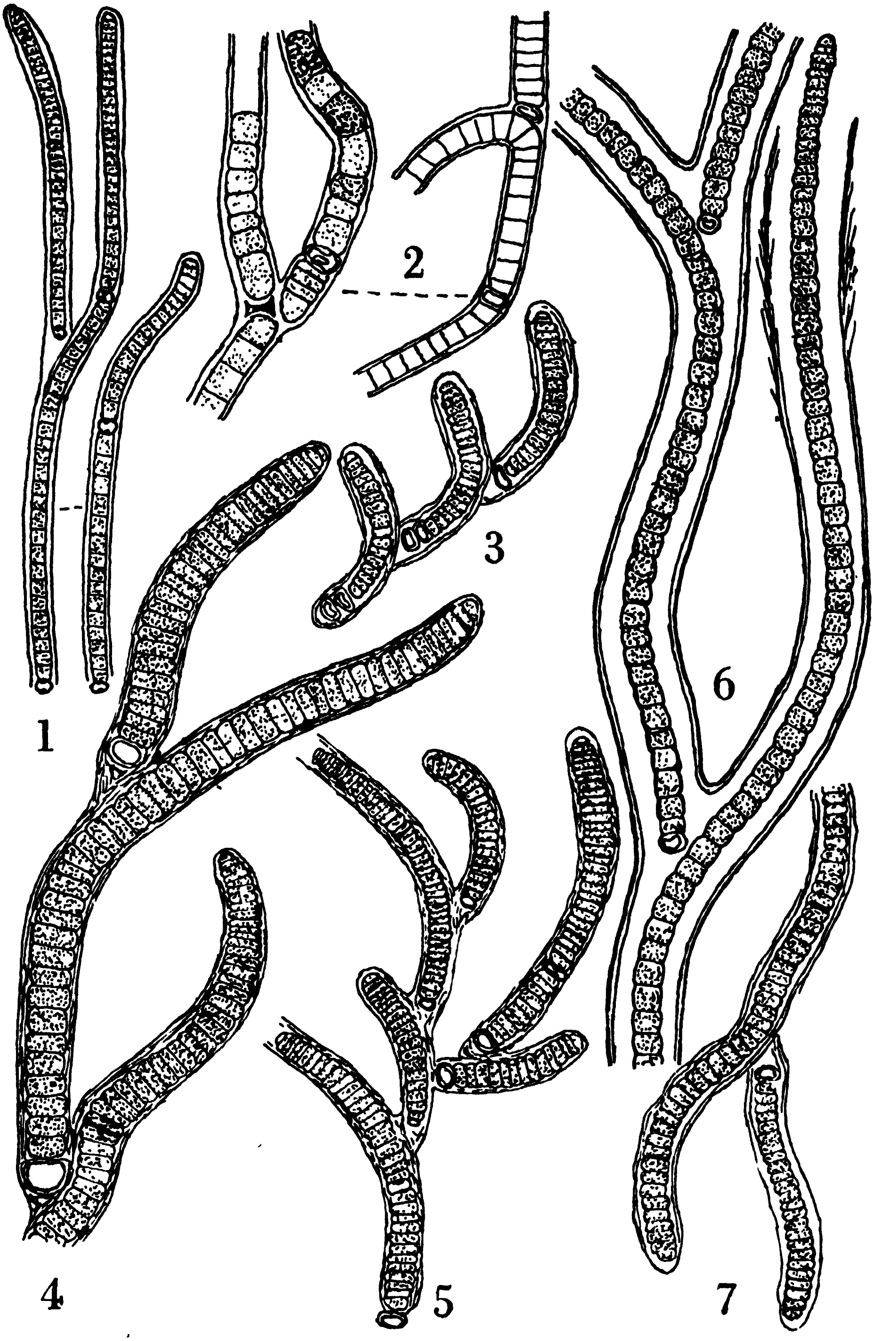

PLATE 103, Figs. 1–7.

1. *Tolypothrix fragilis* (Gardn.) Geitler (after Gardner); 2. *T. rechingeri* (Wille) Geitler (after Wille); 3, 4, 7. *T. byssoidea* (Berk.) Kirchn. (3, 7 after Kossinskaja); (4 after Frémy). 5. *T. bouteillei* (Bréb. et Desm.) Forti (after Frémy); 6. *T. limbata* Thuret (after Frémy).

yellow or when young hyaline outside very rough, thin, in lower gelatinized parts somewhat thicker with lamellation; trichomes blue-green, cylindrical, in older parts somewhat torulose; cells rectangular as long as broad or up to ½ as long as broad; heterocyst gregarious, variable in size.

On Mount Lavinia, near Colombo, Ceylon (Schmidle, *loc. cit.*).

### 10. **Tolypothrix campylonemoides** Ghose

A systematic and ecological account of a collection of blue-green algae from Lahore and Simla, J. Linn. Soc. Bot. Lond., 46: 344, pl. 31, fig. 12, 1924; Geitler, Kryptogamenflora, 726, fig. 467, 1932.

Pl. 95, Fig. 5

Thallus dirty brown, in colour, blue-green, thin, papyraceous; filaments flexuous, 10–12 μ broad; irregularly false branched, sparse, short, erect, single rarely geminate; sheath thin, fragile, at first colourless, later yellowish to brownish; trichome 8–10 μ broad, torulose; cells barrel-shaped, shorter than broad; heterocysts single or intercalary, subspherical, about 11 μ broad and 9.5 μ long; branches functioning as hormocysts.

On tree trunks and in paddyfield soil cultures, Lahore (Ghose 1924, 344); Calcutta (Banerji, 1935, 298).

### 11. **Tolypothrix byssoidea** (Berk.) Kirchner

in Engler and Prantl, Natürlichen Pflanzenfam., I, 1a: 80, 1900; Geitler, Kryptogamenflora, 728, fig. 470, 471a, 1932.

= *Hassallia byssoidea* Berk. in Hass. Brit. Freshw. Alg., 1: 233, pl. 67, fig. 5, 1845; Bornet and Flahault, Revision des Nostocacées hétérocystées, 11b, 1887; Frémy, Myxo. d'Afr. équat. franc., 292, fig. 255, 1929; Cyano. cotes d'Eur., 167, pl. 53, fig. 1a, 1933.

Pl. 103, Figs. 3, 4, 7

Thallus woolly, cushion-like, brownish or blackish; filaments up to 1 mm long, 10–15 μ (rarely up to 17 μ) in diam., irregularly false branched; false branches short, erect, curved; sheath thin, close to the trichome yellowish to brownish, fragile, tubular, sometimes somewhat ocreaceous; trichome 9–11 μ broad, torulose; cells barrel-shaped, ½–⅓ times as long as broad; heterocysts basal, rarely intercalary, single or in twos; spores seen once, in series, ellipsoidal, longer than the vegetative cells, yellowish green.

On tree trunks and on moist soil. — Lahore (Ghose, 1919, 11); Calcutta (Banerji, 1938, 97; Bruhl and Biswas, 1923, 17).

In Bruhl and Biswas' alga the trichome was narrower (8–9 μ broad).

12. **Tolypothrix rechingeri** (Wille) Geitler

in Pascher's Süsswasserflora, 12: 259, 1925; Geitler, Kryptogamenflora, 730, fig. 473a, 1932.

= *Hassallia rechingeri* Wille in Rechinger, Ergebn. Samoa Ins., Denkschr. Ak. Wiss. Wien, 91: 12, pl. 1, figs. 19–26, 1915.

Pl. 103, Fig. 2

Thallus soft, cushion-like, brownish-olive green; false-branching in the basal parts of the thallus, single; filaments erect, 1–2 mm long, 10–16 μ broad with a thin colourless or yellowish; trichome 7–11 μ broad, cells broader than long, or up to ⅓ as long as broad, blue-green or violet; heterocysts round, somewhat flattened, or nearly quadratic.

Shembaganur (Frémy, 1942, 22/23).

13. **Tolypothrix conglutinata** Borzi ex Born. et Flah.

Borzi, Note alla Biol. e Morf. delle Alg. Ficocr., Nuovo Giorn. Bot. ital., 11: 371, 1879; Bornet and Flahault, Revision des Nostocacées hétérocystées, 125, 1887; Forti in De Toni, Sylloge Algarum, 5: 551, 1907; Geitler, Kryptogamenflora, 737, 1932.

Filaments densely entangled, irregularly flexuous, forming a blue-green or a brownish slimy crustaceous thallus, 14–18 μ broad; sheath thick, irregularly broadened, colourless and homogeneous; cells 8–10 μ broad, shorter than long, not constricted at the cross-walls; heterocysts spherical, single.

Type not recorded.

Var. **colorata** Ghose

A Systematic and ecological account of a collection of blue-green algae from Lahore and Simla, J. Linn. Soc. Bot. Lond., 46: 345, pl. 31, fig. 13, 1924.

Pl. 95, Fig. 3

Thallus at first blue-green later brownish green, floccose, tomentose; filaments densely irregularly entangled; trichome 7–9 μ broad, constricted at the cross-walls; cells shorter than broad, branches many, short, flexuous, single or seldom geminate; sheath thick, rough, at first colourless, later yellowish brown; heterocysts somewhat 8 μ broad.

On damp rocks and on moist exposed roots of trees, Simla (Ghose, *loc. cit.*).

Geitler does not think this alga belongs to *T. conglutinata*.

14. **Tolypothrix magna** Bharadwaja

The Taxonomy of *Scytonema* and *Tolypothrix*, Rev. algol., Paris, 7: 177, fig. 7a, 1934.

Pl. 98, Fig. 4

Stratum thin dirty blue-green crust; filaments irregularly curved and densely entangled, 23.1–26.7 μ broad; false branches short, usually single, arising by the side of dead cells, one pored heterocysts or dead cells adjoining such heterocysts, rarely by the side of two pored heterocysts; sheath firm, thick, pigmented, with distinct divergent stratification, 6.8–11 μ thick; trichomes with distinct septa, occasionally constricted at the joints, 9.4–13.6 μ broad; cells flattened, $^1/_3$–$^1/_5$ times as long as broad; heterocysts intercalary (two-pored) and terminal (one-pored), broader than long, terminal heterocysts subspherical, intercalary ones slightly quadratic or transversely ellipsoidal, usually broader than the trichome, 9.4–16.8 μ broad and 6.3–12.5 μ long.

Among other Myxophyceae on the surface of a tank at Nalanda in Ceylon (Bharadwaja, *loc. cit.*).

### 15. **Tolypothrix arencphila** West et West

Welwitsch's Freshw. Afr. Alg. J. Bot. Lond., 35: 267, 1897; Forti in De Toni, Sylloge Algarum, 5: 554, 1907; Frémy, Myxo. d'Afr. équat. franc., 289, 1929; Geitler, Kryptogamenflora, 739, 1932.

Thallus thin, somewhat membraneous, yellowish; filaments densely entangled, flexuous, attenuated at the ends, 14.5–15 (–18) μ broad; false branches sparse, short, lying close to the main filaments; sheath thick, firm, lamellated, yellow to brown; cells 5.5 μ broad, 1¼–2¼ times as long as broad, blue-green; heterocysts single, rectangular.

On damp coarse mud around lawns and ponds, Lahore (Ghose, 1919, 11).

### 16. **Tolypothrix crassa** West et West

*loc. cit.*, 267, 1897; Forti in De Toni, Sylloge Algarum, 5: 553, 1907; Frémy, Myxo. d'Afr. équat. franc., 289, 1929; Geitler, Kryptogamenflora, 740, 1932.

Thallus thick, spongy free-floating, blackish green; filaments 25–27 μ broad, flexuous, densely entangled; sparsely false branched, with short false branches; sheath very thick, firm, distinct, but not divergently stratified, dirty yellow; cells nearly quadratic or double as long as broad, 11.5–14.5 μ broad, blue-green; heterocysts single, nearly quadratic or longer.

On barks and sides of a wall, Peradiniya and Pandure in Ceylon (West and West, 1902, 202).

### 17. **Tolypothrix foreaui** Frémy

Deux Cyanophycées, Trav. Crypt. dedies a Louis Mangin, 105, pl. 2, 1931; Cyanophycées de l'Inde méridionale, Blumea, Suppl. II, 33, 1942.

Pl. 100, Fig. 1

Thallus caespitose, globose, about 3 mm diam., brown or blackish; filaments intricate, about 1 mm long, 14–21 μ broad; repeatedly false branched, branches erect; sheath broad, firm, golden yellow, lamellated, lamellation divergent, above inflated or ocreate; trichome 5–7 μ broad, cylindrical, blue-green; cells 1½–2 times longer than broad; heterocysts solitary, rarely two, ellipsoidal.

Amidst other algae in stagnant waters, Shembaganur (Frémy, *loc. cit.*).

### 18. **Tolypothrix limbata** Thuret

in Bornet and Flahault, Revision des Nostocacées hétérocystées, 124, 1887; Forti, in De Toni, Sylloge Algarum, 5: 556, 1907; Geitler, Kryptogamenflora, 734, fig. 474a, 1932.

Pl. 103, Fig. 6

Thallus floccose, caespitose, blue-green; filament 2–3 mm long, 10–15 μ broad, repeatedly false-branched; false branches erect; sheath colourless or yellowish brown, thick, lamellated, at the apices ocreate outside slimy; trichomes 6–9 μ broad, torulose; cells barrel-shaped, as long as broad or somewhat longer; heterocysts single or in twos.

Shembaganur in Madras state (Frémy, 1942, 22).

### Var. **cylindrica** Ghose

Five more Myxophyceae from Rangoon, J. Indian bot. Soc., 10: 36, figs. 1 and 2, 1931.

Stratum floccose, blue-green; filaments 10–16 μ broad, occasionally branched; sheath colourless or brown, thick, lamellose; cells 5–10 μ broad, cylindrical, as long as broad or longer than broad; heterocysts single or double, globose.

In stagnant water, Kamayut near Rangoon in Burma (Ghose, *loc. cit.*).

## SPECIES INQUIRENDA

### **Tolypothrix binata** Zeller

Algae collected by Mr. S. Kürz in Arracan and British Burma, J. Asiatic Soc., Bengal, 42: 184, 1873; Hedwigia, 12: 174, 1873; Forti, in De Toni, Sylloge Algarum, 5: 555, 1907.

Thallus caespitose, 5–7.5 mm high blue-green; filaments elongated, branches about 5 μ broad; cells distinct in the lower parts, commonly about twice as long as broad, rarely as long as or shorter than broad, subtorulose.

On submerged roots in Eng-ga-na, Kya-Eng, Pegu (Zeller, *loc. cit.*).

*Tolypothrix nodosa* Bharadwaja bears a resemblance to this species; only an examination of type material of *T. binata* can settle this point.

## PETALONEMA Berk.

Gleaning of British Algae, 23, 1883.

Filaments free, variously bent, procumbent or erect, with apical growth and apical cell; trichome broader at the apex; false branching mostly in pairs, between two heterocysts or occasionally in upper parts mostly single and often gehauft; sheath firm, very thick by the placing of one in another of a number of funnel-like pieces, which appears in optical longitudinal section divergent, often on the outside with a thin firm layer; heterocysts intercalary; hormogones present.

Type species: *P. alatum* Berk.

### KEY TO THE SPECIES

1. Filaments up to 64 ( -115) μ broad ........................ 1. *P. alatum* (p. 506)
1. Filaments 24–45 μ broad................................ 2. *P. densum* (p. 507)

### 1. **Petalonema alatum** Berk.

Gleanings of British Algae, 23, pl. 7, fig. 2, 1883; Geitler, Kryptogamenflora, 789, figs. 505 and 506, 1932.

= *Scytonema alatum* (Carm.) Borzi, Morfologia e biologia delle Alghe fichochromacea Nuovo Giorn. bot. ital., 11: 373, 1879; Bornet and Flahault, Revision des Nostocacées hétérocystées, 110, 1887.

Pl. 4, Figs. 1–3, 12

Thallus caespitose, mucilaginous, or single, intermingled with other algae, blackish brown in colour; filaments flexuous, procumbent, or erect, 4–8 mm long, 24–66 (–115) μ broad; false branching mostly geminate, sometimes only one or three, mostly sparse; sheath very thick, with distinct funnel-shaped pieces of mucilage sheath tucked into one another, at the apices forming a very sharp angle with the longitudinal axis of the filament, in older filaments and mostly on the inside parallel with the trichome; sheath when young colourless, when old yellowish to brown, in most trichome parts very dull coloured, often inside brown outside colourless; cells 9–15 μ broad, at the growing region short and barrel-shaped, in the older parts long cylindrical, up to twice as long as broad; heterocysts up to 17 μ broad, truncated spherical to long cylindrical.

Shembaganur, Madras state (Frémy, 1942, 22/36).

### Var. **indicum** Rao, A. R.

Curr. Sci., 13: 260, figs. 1, 2, 1944.

Thallus expanded, cushions 1.5–2 cm thick, impregnated with lime and showing zonations of probably seasonal growth; filaments arranged more or less radially upwards, varying in thickness, 40–90 μ broad, broader at the top and narrower at the base; cells broader than long near the tip of the branch, and gradually decreasing in breadth and increasing in length, lower down constricted at the joints; branching false, single or double, branches running parallel to the parent filament; the branch tip trumpet-shaped; heterocysts present, variable in form.

On irrorated rocks near Chakrata, Dehra Dun Road (A. R. Rao, *loc. cit.*).

### 2. **Petalonema densum** (A. Br.) Migula

Kryptogamenflora, 132, 1907: Geitler, Kryptogamenflora, 793, fig. 509, 1932.

Pl. 101, Figs. 1–3

Thallus dense, cushion-like; filaments more or less entangled up to 1 mm long, 24–40 μ broad, false branches mostly single, very seldom geminate, at the apices, adpressed to the main filament; sheath yellow to brown, often with distinct lamellation; trichomes 6–12 μ broad, slightly constricted at the cross-walls; cells short, at the apex, in parts often longer than broad.

On moist rocks, Nandi Hills ( ! ).

The Nandi Hills alga is broader than the type (filaments 22.3–48.3 μ broad).

## Family MICROCHAETACEAE Lemmermann

Kryptogamenflora der Mark Brandenburg, 3: 196, 1910.

Trichomes with a single row of cells, uniformly broad, with a differentiation of base and apex, apex sometimes slightly narrowed or broadened, without an apical hair; unbranched, sometimes false branches present; sheath distinct enclosing a single trichome; heterocysts intercalary or basal or terminal; hormogones present; spores present.

This family originally included three genera, *Microchaete*, *Aulosira* and *Desmonema*. Geitler (1932, p. 664), however, removed *Desmonema* to the Scyotonemataceae, but included *Hormothamnion* in the Microchaeataceae. Fritsch (1942, 1945) included *Aulosira* in the Nostocaceae. In this connection it may be mentioned that Bornet and Flahault (1888, p. 181) have included *Aulosira* and *Hormothamnion* in the Nostocaceae — which is also adopted in the present treatment — in a subfamily Aulosirae. Microchaetaceae as is circumscribed here includes *Microchaete* ( = *Fremyella*) and *Fortiea* ( = *Leptobasis*). The basis for the separation of this latter genus is well set forth by Elenkin (1915, 1938). While the structure of the trichome and the mode of spore formation (*see* p. 515) support the separation of the two genera, yet the resemblances are so great that the creation of the Leptobasaceae appears to be not warranted. In fact some authors do not even accept the separation of the two genera.

## KEY TO GENERA

1. Trichomes uniformly broad throughout or slightly narrower at the tips *Microchaete* (p. 508)
1. Trichomes with ends generally broader than the rest of the trichomes *Fortiea* (p. 515)

## MICROCHAETE Thuret

Essai class. Nost., Ann. Sci. nat., Bot., ser. 6, 1: 378, 1875; Bornet and Flahault, Revision des Nostocacées hétérocystées, 83, 1887; Geitler, Naturlichen Pflanzenfam., I, la: 159, 1942. *non* Bentham, 1845.

= *Frémyella* De Toni, Noterelle di nomencl. algol., 8: p. 3, 1936.

Trichome single with a distinct sheath, more or less attenuated at the apices, seldom equally broad all through; filaments attached, single or in groups or clusters, seldom with single pseudo-branches false branches; heterocysts basal, seldom intercalary; spores mostly single, seldom in series, away from the heterocysts or near it; hormogones present.

Type species: *M. tenera* Thuret.

Geitler (1942) selected *M. grisea* Thur. as the type.

### KEY TO THE SPECIES

1. Freshwater form .................................................. 3
1. Marine form .................................................. 2
    2. Filaments broader than 12 μ .................. 1. *M. aeruginea* (p. 510)
    2. Filaments narrower .................. 2. *M. grisea** (p. 510)
3. Sheath lamellated.................................................. 8
3. Sheath not lamellated .................................................. 4
    4. Constricted at the cross-walls .................................................. 5
    4. Not constricted at the cross-walls .................................................. 6
5. Filaments 16–18 μ broad.................. 3. *M. uberrima* (p. 511)
5. Filaments 12–12.5 μ broad .................. 4. *M. violacea* (p. 511)
    6. Filaments 19–20 μ broad .................. 5. *M. elongata* (p. 513)
    6. Filaments less broad .................................................. 7
7. Filaments 4.5–5 μ broad .................. 6. *M. aequalis* (p. 513)
7. Filaments 6.8–5 μ broad .................. 7. *M. tenera*** (p. 513)
    8. Filaments 10–16 μ broad .................. 8. *M. calothricoides* (p. 514)
    8. Filaments 12–14 μ broad .................. 9. *M. loktakensis* (p. 515)

* cf. var. *brevis* Bharadw.

** cf. var. *major* Moebius and forma Bharadw.

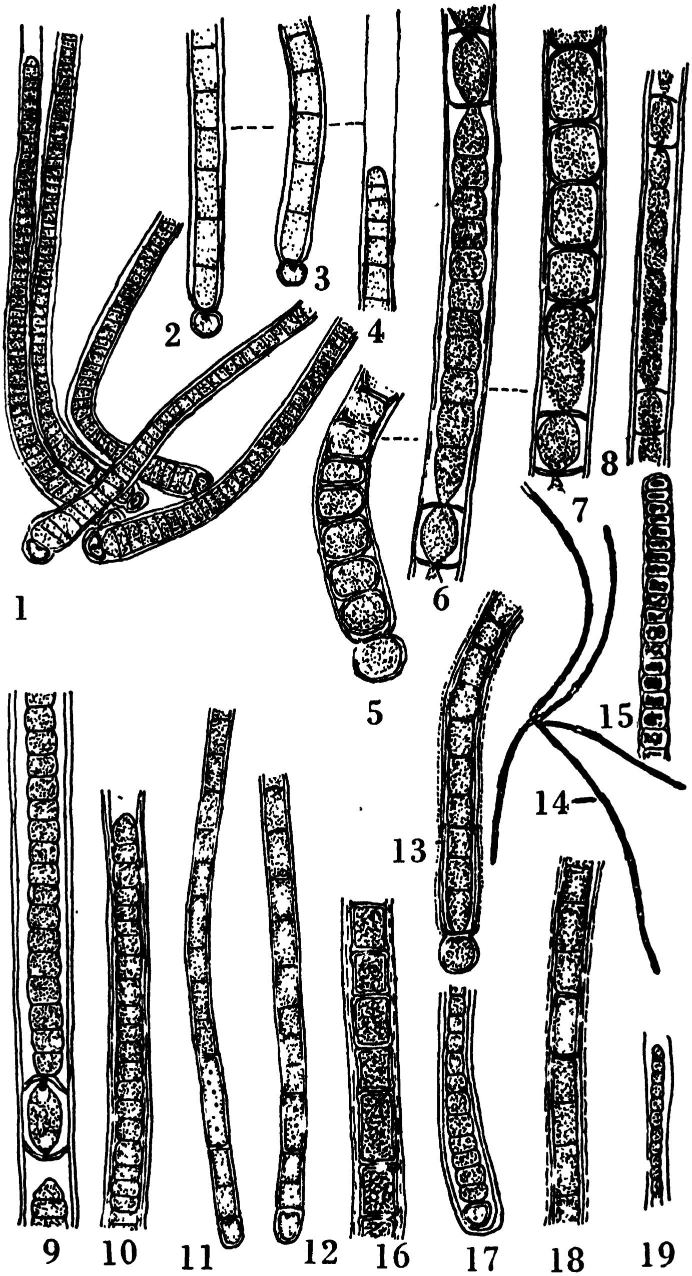

PLATE 104, Figs. 1–19.

1. *Microchaete tenera* v. *tenuis* Bharadw. (after Bharadwaja); 2–4. *M. grisea* v. *brevis* Bharadw. (after Bharadwaja); 5–7. *M. uberrima* Carter (after Carter); 8. *M. uberrima* f. *minor* Carter (after Carter); 9, 17, 19. *M. loktakensis* Bruhl et Biswas (after Bruhl & Biswas); 10, 13, 16, 18. *M. uberrima* Skuja (after Skuja); 11, 12, 14, 15. *M. tenera* Thuret (after Skuja).

### 1. **Microchaete aeruginea** Batters

*Microchaete aeruginea* sp. n., J. Bot., Lond., 30: 86, 1892; Forti, in De Toni, Sylloge Algarum, 5: 486, 1907; Geitler, Kryptogamenflora, 666, 1932; Frémy, Cyano. cotes d'Eur., 165, 1933.

Pl. 61, Figs. 1-3

Filaments often bent, 12 μ broad, up to 300 μ long; sheath uniformly thick, not lamellated, colourless; trichome 6–7 μ broad; cells at the base half as long as broad; heterocysts basal, oblong, or hemispherical.

On dead corals near high tide mark, along with *Cladophora* Shingle island near Pamban (Iyengar and Desikachary, 1944, 50).

The filaments in the Pamban alga are much broader (12.9–16.1 μ broad). Branching is also seen occasionally. Intercalary heterocysts are seen. It is doubtful whether the Pamban alga does not belong to a different species.

### 2. **Microchaete grisea** Thuret ex Born. et Flah.

Thuret, Essai class, nost., Ann. Sci. nat., Bot., ser. 6, 1 :7, 1875; Bornet & Thuret, Notes algologiques, 2: 127, pl. 30, figs. 1-4, 1880; Bornet and Flahault, Revision des Nostocacées hétérocystées, 85, 1887; Forti in De Toni, Sylloge Algarum, 5: 485, 1907; Geitler, Kryptogamenflora, 666, fig. 427, 1932. Frémy, Cyano. cotes d'Eur., 165, pl. 52, fig. 1, 1933.

= *Frémyella grisea* (Thuret) J. De Toni, Noterelle di nomencl. algol., 8: 4, 1936.

Thallus caespitose, tomentose, dull-green, violet when dried; filaments densely entangled, up to 1 mm long, 6–7 μ broad, bent at the base, base swollen or bulbous; sheath thin, close to the trichome continuous, hyaline; trichome 5–6 μ in broad; cells $\frac{1}{2}$–$\frac{1}{3}$ as long as broad; heterocysts basal, hemispherical.

Type not recorded.

### Var. **brevis** Bharadwaja

The Myxophyceae of the United Provinces, I, Proc. Indian Acad. Sci., B, 2: 101, fig. 4D, 1935.

= *Frémyella grisea* var. *brevis* (Bharadwaja) De Toni, J. Diagnoses Algarum novarum, I, Cent. 6: 502, 1939.

Pl. 104, Figs. 2–4

Filaments straight, at the base often curved and swollen, up to 350 μ long, 6.8–8.3 μ broad; sheath thin, and hyaline; trichomes with distinct septa, 5.4–7.3 μ broad; cells discoid, $\frac{1}{2}$–$\frac{1}{3}$ as long as broad; heterocysts basal, single, hemispherical, 6.3–10.5 μ broad.

On *Chara* in a stagnant pond, Banaras (Bharadwaja, *loc. cit.*) and epiphytic on a floating species of *Spirogyra* in a stagnant pond at Ballygunge, Calcutta (Banerji, 1938, 96).

### 3. **Microchaete uberrima** Carter, N.

Freshwater algae from India, Rec. bot. surv. of India, 9: 268, pl. 1, figs. 1–3, 1926; Geitler, Kryptogamenflora, 669, fig. 430, 1932.

= *Frémyella uberrima* (Carter) J. De Toni, Diagnoses Algarum novarum, I, cent. 8: 705, 1939–46.

= *Microchaete uberrima* f. *minor* Carter, *loc. cit.*, pl. 1, fig. 4, 1926.

= *Frémyella uberrima* f. *minor* (Carter) J. De Toni, *loc. cit.* 1939–40.

Pl. 104, Figs. 5–7, 10, 13, 16, 18

Filaments elongate, up to 5 mm long, absolutely cylindrical, decumbent, at their bases stellately arranged, (9–) 16–18 μ broad; sheath firm, brown; trichome (6.5–) 10–14 μ broad, not attenuated; cells generally subquadrate; heterocysts basal and intercalary, cylindrical spherical and slightly adpressed; spores in long series, olivaceous, quadrate to subcylindrical.

Along with filaments of *Spirogyra* and *Oedogonium* in a ditch at the edge of a rice-field, Sadiya (Carter, *loc. cit.*); epiphytic Mandalay in Burma (Skuja, 1949, 32).

Carter (*loc. cit.*) described a form, f. *minor*, found with the type (Pl. 104, Fig. 8). The form differs in the dimensions of the filament (9–11 μ broad) and trichome (6.5–8 μ broad). Skuja (*loc. cit.*) described an alga which has characters intermediate between the type and the forma *minor*. Filaments 10–14 μ broad; sheath 2–5 μ broad, lamellated, lamellae parallel; cells ¾–2½ times as long as broad; heterocysts intercalary ones 8 μ broad and 13–22 μ long; spores many in series quadrate or cylindrical, 9–10 μ broad and 13–25 μ long. The species seems to be highly variable. The diagnosis of the species is amended here to include the form also.

### 4. **Microchaete violacea** Frémy

Myxo. d'Afr. équat. franc., 284, fig. 250, 1929; Geitler, Kryptogamenflora, 670, fig. 431, 1932.

= *Frémyella violacea* (Frémy) De Toni, Noterelle di Nomencl. algol., 8: 4, 1936.

Filaments single or 5–6 together with other algae, straight or slightly curved, up to 2 mm long, uniformly broad, 12–12.5 μ broad sheath thin, firm, colourless, not lamellated; trichomes 9–10 μ broad, violet, slightly constricted at the cross-walls; cells in the lower parts 1.2–1.5 times as long as broad

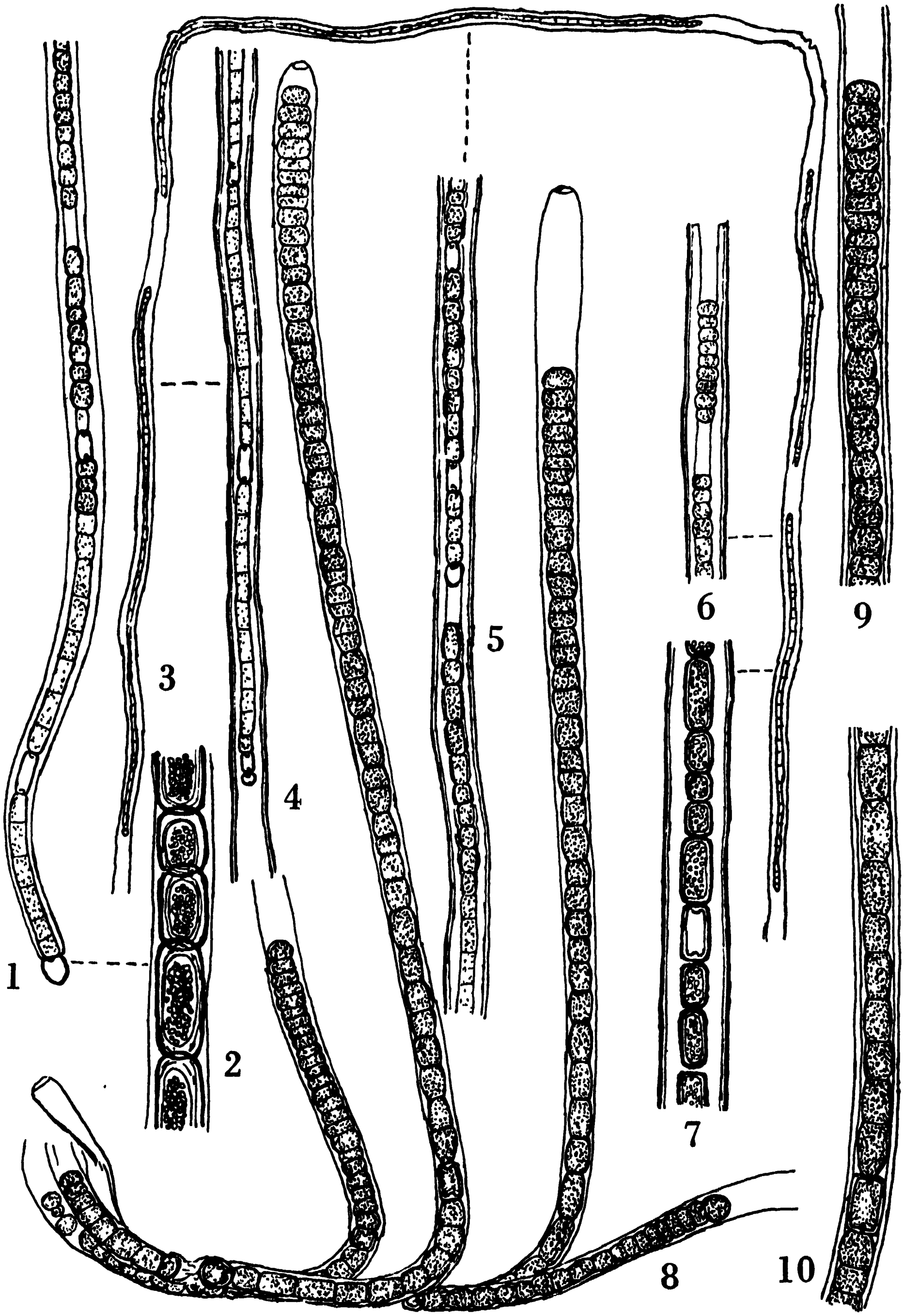

PLATE 105, Figs. 1–10.

1–2. *Microchaete tenera* Thuret (after Frémy); 3–7. *M. elongata* (Frémy) comb. nov. (after Frémy); 8–10. *Fortiea incerta* Skuja (after Skuja).

subquadrate, above cylindrical; heterocysts basal ones compressed-spherical, intercalary ones rectangular, double as long as broad, rarely subquadrate, single; spores intercalary mostly 2–3 or more, rarely single, subquadrate, away from the heterocyst, about 10 μ broad, 10–18 μ long, with smooth colourless outer membrane.

Floating in stagnant rainwater in flowerpot, Calcutta (Banerji, 1938, 96).

5. **Microchaete elongata** (Frémy) comb. nov.

= *Frémyella elongata* Frémy, Cyanophycées de l'Inde méridionale, Blumea, suppl. 2: 30, fig. 6, 1942.

Pl. 105, Figs. 3–7

Filaments long, forming a caespitose, woolly, thallus, attached to aquatic plants, loosely intricate, about 20 (19–20) μ broad; sheath sufficiently broad, hyaline, homogeneous, coloured violet by chlor-zinc-iodide, trichomes 11–14 μ broad, apex not at all or hardly broadened; not constricted at the cross walls except at the apices; cells cylindrical, 1½–3 times longer than broad, in the apical parts longer or shorter than broad; heterocysts terminal, basal or intercalary, basal ones straight and subhemispherical, near basal ones subquadrate or elongate-cylindrical, intercalary ones numerous, generally long cylindrical, rarely elliptical; spores generally in long series; interrupted by heterocysts, subquadrate, 1½–2½ times as long as broad, epispore broad, smooth, lamellated, colourless; contents with large granules; hormogones short with 10–15 cells.

On aquatic plants in the environs of Shembaganur, Madras State (Frémy, *loc. cit.*).

6. **Microchaete aequalis** (Frémy) comb. nov.

= *Frémyella aequalis* Frémy, Cyanophycées de l'Inde mériodionale, Blumea, suppl. 2: 32, fig. 7, 1942.

Pl. 81, Fig. 16

Thallus expanded, blackish blue; filaments sufficiently elongated, more or less intricate, base erect, 4.5–5 μ broad; sheath thin, close, papery, colourless, or rarely yellowish or brownish, coloured blue by chlor-zinc-iodide trichome uniform, 3–3.5 μ broad, not constricted at the cross walls; cells 2–4 times as long as broad; spores and hormogones not seen.

On submerged objects in standing waters in the environs of Shembaganur (Frémy, *loc. cit.*).

7. **Microchaete tenera** Thuret ex Born. et Flah.

Thuret, Essai class. nost., Ann. Sci. nat. Bot., Ser., 6, 1: 378, 1875; Bornet and Thuret, Notes algologique, 2: 129, pl. 30a, 1880; Bornet and Flahault, Revision des Nostocacées hétérocystées, 84, 1887; Forti in De Toni, Sylloge Algarum 5: 482, 1907; Frémy, Myxo d'Afr. équat. franc., 280, fig. 248, 1929; Geitler, Kryptogamenflora, 668, fig. 429, 1932.

= *Frémyella tenera* (Thuret) De Toni, J. Noterelle di nomencl. algol., 8: 4, 1936.

(Pl. 105, Figs. 1, 2)

Filaments up to 1 mm long, single or in small stellate clusters, 6–7 (–8.5) μ broad, slightly bent, prostrate at the base; sheath thin, close to the trichome, hyaline, unlamellated; trichome 5 μ broad, blue-green; cells at the base twice as long as broad, at the apices as long as broad; heterocysts basal and intercalary, nearly spherical or cylindrical, 6 μ broad, 6–8.5 μ long; spores single or in series, basal or intercalary, cylindrical with brownish wall, 6–7.5 μ broad, 13–17 μ long.

On wet soil of lawns, Benaras (Rao, C. B., 1937b, 351); in the environs of Shembaganur (Frémy, 1942, 26); on submerged plant parts of *Limnanthemum nymphaeoides,* Royal lakes, Rangoon (Skuja, 1949, 32).

Rao, C. B., (*loc. cit.*) described a form of this species which resembles to some extent var. *major* Moebius (Abh. d. Seuckenb. naturf. Ges., 343, pl. 2, figs. 2–4, 1894).—Filaments 10–12 μ broad; trichomes 8 μ broad, slightly constricted at the joints; heterocysts 8 μ broad, and 12–20 μ long.

### Var. **tenuis** Bharadwaja

The Myxophyceae of the United Provinces, I, Proc. Indian Acad. Sci., 2B: 102, fig. 4 A-C, 1935.

= *Frémyella tenera* (Thuret) J. De Toni, var. *tenuis* (Bharadw.) J. De Toni, Diagnoses Algarum novarum, I, Cent 6: 503, 1939.

Pl. 104, Fig. 1

Filaments up to 250 μ long, up to 4.2 μ broad; trichome 3.1–3.6 μ broad; heterocysts not cylindrical, 3.6–4.2 μ diam.

On floating dead leaves, in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

### 8. **Microchaete calothrichoides** Hansgirg

Beih. bot. Cbl., 18: 494, 1905; Forti in De Toni, Sylloge Algarum, 5: 483, 1907; Geitler, Kryptogamenflora, 671, 1932.

Filaments 10–16 μ broad, seldom up to 20 μ broad, single or in tufts, forming a dirty greyish green thallus, straight or curved; sheath thick, lamellated often more or less incrusted, colourless; cells at the base of filaments 6–8 μ broad, ⅓ to as long as broad, distinctly constricted at the cross-walls, olive coloured, heterocysts mostly basal, nearly oval to long ellipsoidal, 6 μ broad, up to 8 μ long.

Adhering to the surface of submerged leaves in a stagnant pool Lahore (Ghose, 1924, 242); in cultures of paddyfield soil, from Goregaon near Bombay (Gonzalves and Gangla, 1949, 54).

### 9. **Microchaete loktakensis** Bruhl et Biswas

Algae of the Loktak lake, Mem. Asiatic Soc. Bengal, n. s. 8: 265, pl. 1, fig. 8a-c, 1926.

(Pl. 104, Figs. 9, 17, 19)

Filaments aggregated, long, uniformly cylindrical, a little broader at the base (2 μ), flexuous, briefly decumbent at the base, 12–14 μ broad, above about 8 μ broad, at the apical portions about 6 μ broad, sheath 1.5–2.3 μ broad, with lamellae, colourless, to pale blue green; trichome below 6–8 μ broad, with cells 1–1½ as long as broad, and 6–10 μ long, above about 8 μ broad and cylindrical cells, 1½–2 as long as broad and 8–16 μ long; heterocysts generally basal, spherical to ellipsoidal, 6–9 μ diam., intercalary heterocysts absent or rare, 16–24 μ long, 8 μ broad; cells contents granular.

Loktak lake, Assam (Bruhl and Biswas, *loc. cit.*).

## FORTIEA De Toni, J.

Noterelle di nomencl. algol., 8: 3, 1936.

= *Leptobasis* Elenkin. Note sur une algue nouvelle *Leptobasis caucasica* Elenk., (gen. et sp. nov.) sui vie de la revision critique du genre *Microchaete* Thur. Bull. Jard. Bot., 15(1): 6–22, 1915. *non* Dulac.

Filaments unbranched, trichomes with a firm sheath, attenuated at the base, broadened at the apices, with a basal and intercalary heterocysts, generally attached by the basal end; hormogones and spores present.

Type species: *F. caucasica* (Elenkin) De Toni, J.

The genus bears a close resemblance to Scytonemataceae where growth is apical and the apical portions are broader and not attenuated. Spores were not originally known. In a *Fortiea* from South India spores were observed. There were a few together in series on either side of the intercalary heterocysts. These are liberated by the death of the vegetative cells and often the two spores on either side of the heterocyst remain attached to the heterocyst. These spores were also found to germinate *in situ*.

### KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Filaments 7–9.5 μ broad below and up to 14 μ broader above .. | 2. *F. incerta* (p. 516) |
| 1. | Filaments narrower .......................................... | 1. *F. bossei* (p. 516) |

1. **Fortiea bossei** (Frémy) comb. nov.

= *Frémyella bossei* Frémy, Cyanophycées de l'Inde mériodinale, Blumea, suppl. 2: 27, fig. 5, 1942.

Pl. 82, Figs. 13–15 & Pl. 101, Figs. 4–7

Filaments sparse, long, flexuous; sheath hyaline, thick and with parallel stratification; cells 2–3 μ broad, not constricted at the cross-wall, 3–10 μ long, at the apices broader and up to 8 μ broad and constricted at the cross-walls, shorter; heterocysts common, single or in two, rectangular, 3–5 μ broad, 4.5–15 μ long, rarely subquadrate; hormogones formed terminally, 7 μ broad, up to 150 μ long, with short cells.

Among filaments of *Zygnema* in freshwater, Shembaganur (Frémy, *loc. cit.*). on dripping rocks, Kunnakudi ( ! ) and Courtallum ( ! ).

Spores were observed in the Kunnakudi and Courtallum material. These are formed in series centripetally. They are 3.93–5.24 μ broad and usually cylindrical sometimes quadrate or subquadrate. The epispore is smooth and brownish in colour. Germination of spore was observed in the Courtallum material.

2. **Fortiea incerta** Skuja

Zur Süsswasseralgenflora Burmans, 30, pl. 3, figs. 4–6, 1949.

Pl. 105, Figs. 8–10

Filaments many in caespitose clusters, rarely solitary, more or less erect, unbranched, attached to the substratum by the base, base and apices clearly dilated, 160–650 μ or more long, 7–9.5 μ broad below, and up to 14 μ broad above; sheath thin, about 1 μ thick, unlamellated, firm, colourless; trichome in basal part 5.5–6 μ broad, and at the apex 11 μ broad, clearly constricted at the cross-walls; cells as long as or twice as long as broad, 6–16 μ long, above ¾–½ as long as broad, contents olivaceous, or pale blue-green; heterocysts basal, rarely intercalary, single or two together, globose or cylindrical and discoid, yellowish 8–10 μ broad and 8–15 μ long; spores not seen; hormogones short or unicellular formed from the apices.

On submerged water plants, in lake, Rangoon, Burma (Skuja, 1949, 30).

## Family RIVULARIACEAE Rabenhorst

Fl. Eur. Algarum, 2: 200, 1868.

Trichomes with a single row of cells, apices generally attenuated or tapering in a hair, unbranched or false branched, sometimes with a distinct intercalary meristematic region and trichothallic growth; hair with elongated more or less vacuolated cells; heterocysts present or absent, when present basal, intercalary heterocysts also present in some; hormogones present; spores present or absent, when present single or in series.

Bornet and Flahault (1886, 340) includes ten genera, *Polythrix, Isactis, Sacconema, Brachytrichia, Leptochaete, Amphithrix, Gloeotrichia, Dichothrix, Rivularia* and *Calothrix*. Kirchner (1898) and Forti (1907, p. 597) added *Loefgrenia* Gomont and they do not recognise *Gloeotrichia* as a distinct genus. Later *Hammatoidea* West et West and *Tapinothrix* Saug. have been added by Lemmermann (1910) and Geitler (1925, 1932, 1942). *Raphidiopsis* has been included in this family by Fritsch and Rich (1924) (*see* however, p. 420).

Elenkin (1936, 1949) separates *Leptochaete, Homoeothrix* and *Amphithrix* to Homoeotrichaceae and *Loefgrenia* to Loefgreniaceae. These two families are placed under Oscillatoriales as a homocystous family. The Rivulariaceae includes *Calothrix, Rivularia* and *Gloeotrichia*. Geitler however, accepts the transfer of *Loefgrenia* to Loefgreniaceae. Poljansky (1934, 1937, also in Elenkin, 1949, pp. 997–1184) includes *Dichothrix, Isactis,* and *Sacconema* in the genus *Calothrix*. He divides the genus into three sections *Eucalothrix* Born. and Flah., *Dichothrix* (Zanrad.) v. Poljansky and *Isactis* (Thur.) Poljansky.

The family here consists of *Homoeothrix, Calothrix, Dichothrix, Rivularia, Gloeotrichia* and *Leptochaete*. *Brachytrichia* is included in the Mastigocladaceae and the genus *Raphidiopsis* is included in the Nostocaceae.

## KEY TO THE GENERA

1. With heterocysts .................................................. 2
1. Without heterocysts .................................................. 5
    2. Filaments in a spherical or hemispherical thallus .................................................. 4
    2. Filaments free, simple or forming dichotomously branched corymbose thallus .................................................. 3
3. Trichomes single in a sheath, simple or distinctly false branched, false branches free *Calothrix* (p. 522)
3. More than one trichome in a sheath, filaments branched false, branches coalescent. *Dichothrix* (p. 544)
    4. Spores not known .................................................. *Rivularia* (p. 548)
    4. Spores commonly formed, single, large .................................................. *Gloeotrichia* (p. 553)
5. Filaments with a chroococcaceous condition at the base ........ *Leptochaete* (p. 521)
5. Filaments without a chroococcaceous condition at the base .... *Homoeothrix* (p. 517)

## **HOMOEOTHRIX** (Thuret) Kirchner

Engler-Prantl, Natürlichen Pflanzenfam., I, 1a: 87, 1898.

Trichome unbranched or at the base or seldom above false branched; filaments erect in a bundle forming a crustaceous cushion shaped or turf like thallus; heterocysts and spores absent.

Type species: *H. juliana* (Menegh.) Kirchner.

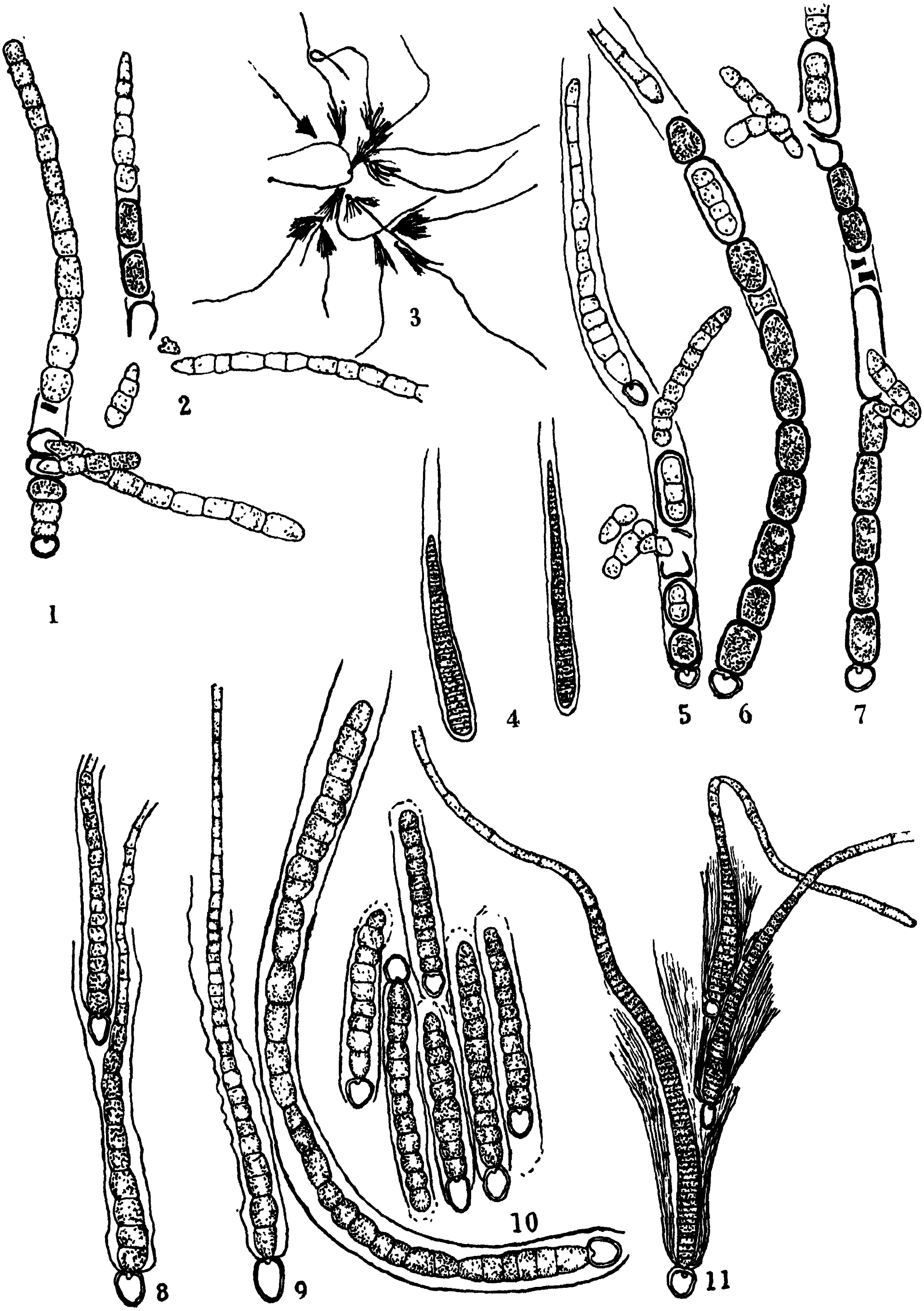

PLATE 106, Figs. 1–11.

1, 2, 5–7. *Calothrix javanica* De Wilde.; 3, 11. *Rivularia manginii* Frémy; 4. *Homoeothrix hansgirgi* (Schmidle) Lemm.; 8, 9. *Rivularia beccariana*; 10. *Calothrix membranacea* Schmidle. (all orig.).

## KEY TO THE SPECIES

- 1. Filaments 10–15 μ broad .................................. 1. *H. juliana* (p. 519)
- 1. Filaments narrower .................................................. 2
    - 2. Filaments 5–10 μ broad .......................... 2. *H. africana* (p. 519)
    - 2. Filaments 4 μ broad ............................. 3. *H. hansgirgi* (p. 521)

### 1. **Homoeothrix juliana** (Menegh.) Krichn.

Engler-Prantl. Natürlichen Pflanzenfam, I, 1a, 348, 1898; Frémy, Myxo. d'Afr. équat. franc., 244, fig. 218, 1929; Geitler Kryptogamenflora, 575, fig. 359, 1932.

= *Calothrix juliana* (Menegh.) Bornet and Flahault, Revision des Nostocacées hétérocystées, 348, 1886.

= *Leibleinia juliana* Kütz., Bot. Zeit., 194, 1847.

Pl. 107, Fig. 7

Filaments single or many together forming a olive coloured thallus, when dried amethyst coloured, erect, rigid, unbranched, 10–15 μ broad, up to 2 mm long, thickened at the base; sheath thin, close to the trichome, colourless, not lamellated; trichomes 9–12.5 μ broad, produced into a long hair and fragile; cells discoid, up to ⅓–½ as long as broad; hormogones 4–5 times as long as broad, 30–60 μ long.

On *Naias* etc., Salt lakes, Calcutta (Martens, 1871a, 173; Prain, 1905, 333; Biswas, 1926, 27); in an artificial tank, Perediniya, Ceylon (West and West, 1902, 200).

### f. **tenuis** Singh, R. N.

An investigation into the algal flora of paddy-field soils of the United Provinces–I, Indian J. Agric. Sci. 9: 58, 1939a.

Filaments 9.9–12 μ broad; trichomes 6.6–7 μ broad, cells 3.3–4 μ long.

In cultures of paddy-field soils from Mirzapur, Gorakhpur, and Benaras districts (Singh, *loc. cit.*).

### 2. **Homoeothrix africana** West, G. S.

Ann. S. Afr. Mus., 9: 68, figs. 36, 37, 1912; Geitler, Kryptogamenflora, 576, 1932.

Filaments single, nearly straight, mostly short, at the base 7.8–11.5 μ broad; sheath close to the trichome, firm in young ones, colourless, in older ones lamellated, about 2 μ thick and yellowish brown; trichome without a swelling at the base, attenuated to a short hair, not constricted at the cross-walls, at the base 5.8–6.3 μ broad; cells at the base of the trichome somewhat shorter than long, above up to 1½ times as long as broad.

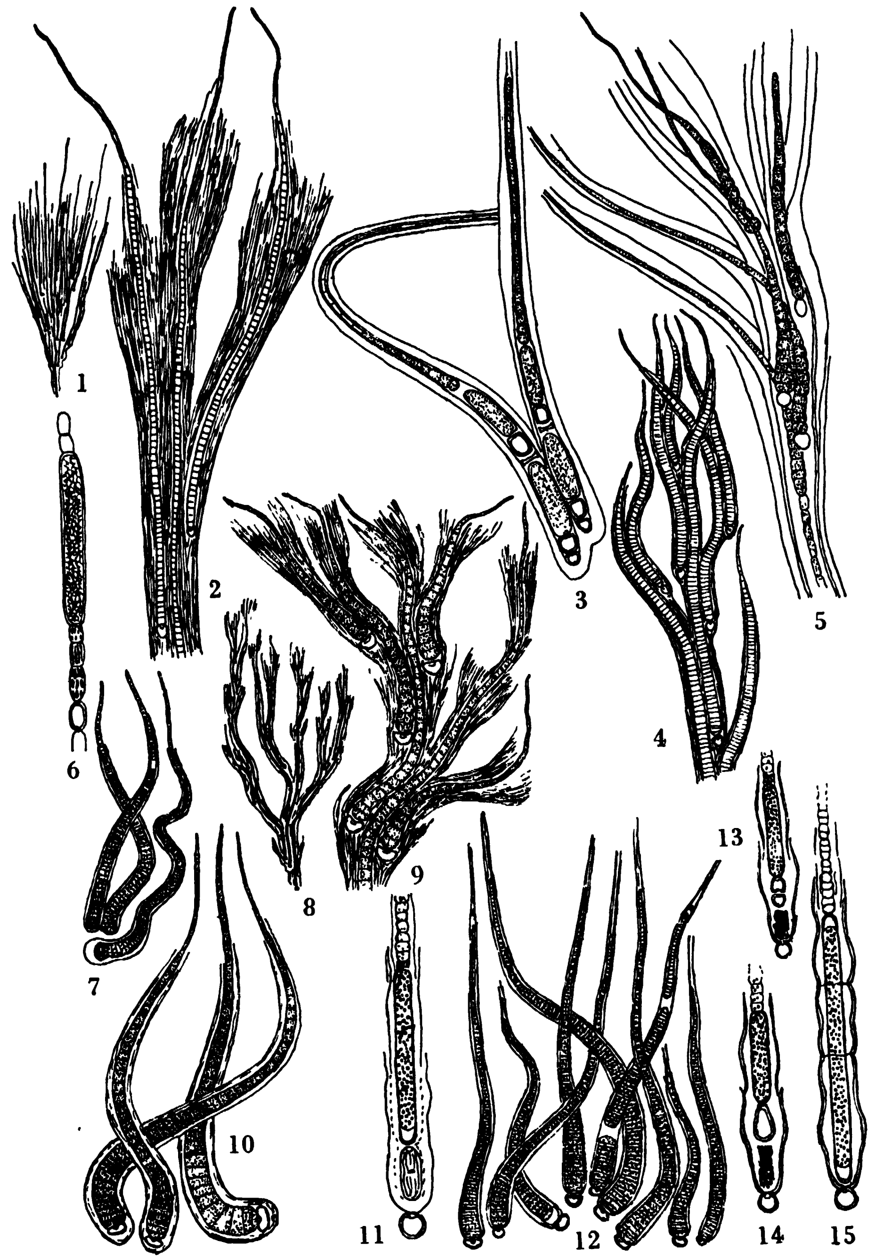

PLATE 107, Figs. 1–15.

1, 2. *Dichothrix compacta* Born. et Flah. (after Frémy); 3. *Calothrix wembaerensis* Hieron & Schmidle (after Schmidle from Kirchner); 4. *Dichothrix orsiniana* (Kütz. ) Born. et Flah. (after Frémy); 5, 8, 9. *D. gypsophila* (Kütz.) Born. et Flah. (5 after Kirchner); (8, 9 after Frémy); 6. *Aphanizomenon flos-aquae* (L.) Ralfs (after Klebahn); 7. *Homoeothrix juliana* (Menegh.) Kirchner (after Frémy); 10. *Calothrix fusca* (Kütz.) Born. et Flah. (after Frémy); 11, 13–15. *Gloeotrichia natans* Rabenh. (after Poljansky from Elenkin); 12. *Calothrix viguieri* Frémy (after Frémy).

Along with *Plectonema wollei,* in a pond in Mandalay, Burma (Skuja, 1949, 25).

Skuja's alga differs from the type in the somewhat broader trichome (6–8 μ broad in the lower part and 4–5 μ broad in the middle part and cells up to 3 times as long as broad) and in the prominent hair.

### 3. **Homoeothrix hansgirgi** (Schmidle) Lemmermann

Kryptogamenflora der Mark Brandenburg, 3: 240, 1910; Geitler, Kryptogamenflora, 576, fig. 361, 1932.

= *Calothrix hansgirgi* Schmidle, Allgm. bot. Zeitschr., 35, 1900a; Über einige von Prof. Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 174, fig. 22, pl. 9, 1900b.

Pl. 106, Fig. 4 & Pl. 112, Fig. 4

Filaments many growing with other algae, unbranched, erect, about 4 μ bread, 20–60 μ (–100 μ) long; sheath thin, colourless; trichomes ending in a short hair; cells very short.

On plants and stones in a lake, near Danger Point, Matheran, Bombay (Schmidle, *loc. cit.*) and on the rocky bed of a mountain stream, Tirupati ( ! ).

## LEPTOCHAETE Borzi

Morfologia e biologia delle Alghe ficochromacee, Nuovo Giorn. bot. ital., 14: 298, 1882; Bornet and Flahault, Revision des Nostocacées hétérocystées, 341, 1886.

Filaments unbranched mostly forming a crustaceous thallus, at the basis the individual cells distinct and separated, division in three directions; heterocysts absent; spores not known; hormogones present.

Type species: *L. crustacea* Borzi.

Only one species known from the region.

### **Leptochaete hansgirgi** Schmidle

Allg. bot. Zeitschr., 34, 1900a; Über einige von Prof. Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 174, pl. 9, fig. 22, 1900a.

Thallus caespitose, expanded epiphytic, many layered, thin, soft; cells 2–4 μ diam., spherical, irregularly disposed, 2–4–6 together in a layer, filaments ascending, aggregated on the outside, very thin, about 1.7–2 μ broad, blue-green, more horizontally expanded; sheath hyaline at the base yellowish, 120–200 μ long, not attenuated at the ends, cells short, rectangular, with indistinct side walls, later broadening at the base, up to 4 μ; sheath indistinct; cells torulose, filaments attenuated at the apices about 2 μ broad.

Epiphytic on leaves in Victoria gardens, Bombay (Schmidle, 1900).

Geitler (1942, p. 176) keeps this genus under ' Anhang '. Possibly these may represent stages or otherwise of *Homoeothrix* species.

## CALOTHRIX Ag.

Syst. Alg., 24, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 345, 1886.

Filaments single or in small bundles, caespitose, tomentose, pulvinate, or penicillate; filaments arranged more or less parallel, mostly erect, unbranched or seldom false-branched; sheath mostly firm, sometimes seen only at the base; heterocysts mostly basal, seldom intercalary; spores when formed single or in series, next to the basal heterocyst.

Type species: *C. confervicola* (Roth) Ag.

Poljansky (in Elenkin, 1949) enlarges the limits of the genus to include in it *Dichothrix* Zanard., *Isactis* Thur., and *Sacconema* Borzi.

Fan (Rev. algol., Paris, (3): 154–178, 1956) made an extensive study of the genus and recognises only six species as against the 23 species recognised by Bornet and Flahault. Fan considers the rest of the species as growth forms of one or the other six species or as species of other genera. The six species are *Calothrix juliana, C. pilosa, C. parietina, C. adscendens, C. confervicola* and *C. crustacea.* The position of the post Bornet and Flahault species is not known nor has he indicated the full synonymy of his well-considered species.

### KEY TO THE SPECIES

1. Marine .......... 2
1. Freshwater .......... 4
   2. Heterocysts basal .......... 3
   2. Heterocysts basal and intercalary .......... 1. *C. crustacea* (p. 523)
3. Trichomes swollen at the base .......... 2. *C. contarenii* (p. 524)
3. Trichomes not swollen or only a little swollen at the base . 3. *C. scopulorum* (p. 524)
   4. Spores present .......... 5
   4. Spores not known .......... 8
5. Spores single .......... 7
5. Spores more than one .......... 6
   6. Spores 4 μ broad .......... 4. *C. javanica* (p. 525)
   6. Spores 10–16 μ broad .......... 5. *C. wembaerensis* (p. 525)
7. Spores 6.3–8.4 μ broad .......... 6. *C. bharadwajae* (p. 526)
7. Spores 10.5–12.5 μ broad .......... 7. *C. ghosei* (p. 526)
   8. Filaments distinctly swollen at the base .......... 9
   8. Filaments not so swollen at the base .......... 19

9. Filaments 10 μ or more thick at the base ...... 10
9. Filaments narrower ...... 13
10. Trichome above 8 μ broad ...... 11
10. Trichomes below 8 μ broad ...... 12
11. Trichome 6–7 μ broad ...... 8. *C. stellaris* (p. 527)
11. Trichome 7–8 μ broad ...... 9. *C. fusca* (p. 527)
12. Trichome 8–10 μ broad ...... 10. *C. castellii* (p. 529)
12. Trichome 10–13 μ broad ...... 11. *C. clavatoides* (p. 531)
13. Filaments about 7 μ broad ...... 14
13. Filaments more than 7 μ broad ...... 16
14. Trichomes with a hair ...... 28
14. Trichomes without a hair ...... 15
15. Trichome long and attenuated gradually ...... 12. *C. elenkinii* (p. 531)
15. Trichome short, not gradually attenuated ...... 13. *C. brevissima* (p. 533)
16. Sheath thick, lamellated, thermal ...... 14. *C. thermalis* (p. 533)
16. Sheath thin, not lamellated, non-thermal ...... 17
17. With a hair ...... 18
17. Without hair, not attenuated ...... 5. *C. wembaerensis* (p. 525)
18. Filaments ½–1 cm. long, gradually tapering ...... 15. *C. gardneri* (p. 535)
18. Filaments shorter, distinctly attenuated ...... 16. *C. braunii* (p. 535)
19. Endophytic in the mucilage of other algae ...... 17. *C. geitonos* (p. 537)
19. Not endophytic ...... 20
20. Filaments broader than 10 μ ...... 21
20. Filaments narrower than 10 μ ...... 26
21. Sheath not clearly seen or thin and unlamellated ...... 22
21. Sheath thick and unlamellated ...... 23
22. Trichome 7–8 μ broad, more or less without a sheath 18. *C. scytonemicola* (p. 537)
22. Trichome 6–7 μ broad, sheath thin and unlamellated 16. *C. braunii* (p. 535)
23. Filaments above 15 μ broad ...... 24
23. Filaments less than 15 μ broad ...... 25
24. Trichomes about 8.5 μ broad, cells very short .. 19 *C. breviarticulata* (p. 537)
24. Trichomes 10–15 μ broad, cells not very short ...... 20. *C. viguieri* (p. 538)
25. Trichome 5–10 μ broad ...... 21. *C. parietina* (p. 538)
25. Trichome 7–8 μ broad ...... 22. *C. dolichomeres* (p. 540)
26. Cells longer than broad, filaments about 8 μ broad.. 23. *C. weberi* (p. 540)
26. Cells shorter than long ...... 27
27. Trichomes forming a membranous thallus ...... 24. *C. membranacea* (p. 542)
27. Trichomes single or a few together, not forming a membranous thallus ...... 29
28. Trichomes very long, in the mucilage of other algae 25. *C. gloeocola* (p. 542)
28. Trichomes very short, free ...... 26. *C. clavata* (p. 542)
29. Trichome 3.5–4 μ broad ...... 27. *C. epiphytica* (p. 543)
29. Trichome 4–4.5 μ broad ...... 28. *C. marchica* (p. 543)

### 1. **Calothrix crustacea** Thuret

in Bornet and Thuret, Notes algologiques, 1: 13, pl. 4, 1876; Bornet and Flahault, Revision des Nostocacées hétérocystées, 359, 1886; Forti in

De Toni, Sylloge Algarum, 5: 613, 1907; Geitler, Kryptogamenflora, 601, fig. 375b, 1932; Frémy, Cyano. cotes d'Eur., 146, pl. 38, fig. 2, 1933.

Pl. 111, Figs. 10-11

Thallus caespitose, blackish green to brown; filaments 1–2 mm long, 12–20 μ rarely up to 40 μ broad, at the base slightly swollen, often extended at both ends into a long hair; sheath broad, colorless to yellowish brown, in older filaments lamellated, generally ocreate, at the ends dilated; trichomes 8–15 μ broad; cells short; heterocysts basal, one to three, and intercalary; spores in series, long cylindrical, oblong, smooth.

Growing on shells among other algae, Krusadai island. (Iyengar and Desikachary, 1944, 49), Cape Comorin (Venkataraman, 1957, 473).

### 2. **Calothrix contarenii** (Zanard.) Bornet et Flahault

Revision des Nostocacées hétérocystées, 355, 1886; Forti in De Toni, Sylloge Algarum, 5: 610, 1907; Geitler, Kryptogamenflora, 600, 1932; Frémy, Cyano. cotes d'Eur., 142, pl. 3b, fig. 4, 1933.

Pl. 111, Figs. 2, 5–8

Thallus crustaceous, compact, orbicular, firm, dull green, smooth; filaments densely arranged, parallel, erect, up to 1 mm high, flexuous, at the base 9–15 μ broad, base decumbent and swollen; sheath thick colorless to yellowish brown, unlamellated, or lamellated and dilated like a funnel; trichome 6–8 μ broad, ending in a long hair; cells as long as broad or somewhat shorter; heterocysts 1–2, basal.

On dead coral stones, Pamban and Krusadai island (Iyengar and Desikachary, 1944, 48).

The South Indian form is slightly broader than the type (Filaments 11.8–19.6 μ broad and trichomes (6.6–) 9.2–13.1 (–15.7) μ broad).

### 3. **Calothrix scopulorum** (Weber et Mohr.) Ag. ex Born. et Flah.

Agardh, Syst. Alg., 70, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 353, 1886; Forti in De Toni, Sylloge Algarum, 5: 608, 1905; Geitler, Kryptogamenflora, 600, fig. 374, 1932; Frémy, Cyano. cotes d'Eur., 143, pl. 35, fig. 2, 1933.

Pl. 111, Fig. 9

Thallus caespitose, expanded dull green, or olivaceous; filaments more or less tortuous, 1 mm high, 10–18 μ broad, slightly swollen at the base; sheath thick, colorless to yellowish brown, unlamellated or lamellated and dilated like a funnel; trichome 8–15 μ broad, attenuated into a hair; cells subquadrate to ⅓ as long as broad; heterocysts basal, often many, 1–3; hormogones many, 4–5 times as long as broad.

On dead coral stones, Krusadai island (Iyengar and Desikachary 1944, 49).

The krusadai alga is a narrower form.

### 4. **Calothrix javanica** de Wilde.

Alg. rapport. par J. Massart, Ann., Jardin Buitenz., suppl. 1: 41, pl. 22, figs. 6–13, 1897; Les Algues de la Flore de Buitenz., 13, pl. 15, figs. 6–13, 1900; Forti in De Toni, Sylloge Algarum, 5: 620, 1907; Geitler, Kryptogamenflora, 613, 1932.

Pl. 106, Figs. 1, 2, 5-7 & Pl. 115, Figs. 3, 4

Filaments single, in the mucilage of other algae, with a distinct colorless, unlamellated sheath, gradually attenuated to a pointed apex, at the base not swollen; trichomes 4–6 μ broad, ending in a thin hair; heterocysts basal, 4–5.5 μ broad; spores single or two together, about 4 μ broad and 6–10 μ long.

With *Phormidium tenue* in a hot spring, at Setapak, Kuala Lumpur, Malaya (Biswas, 1929, 492); with *Phormidium* and *Gloeocapsa* on the shells of *Taia Intha,* Inle lake, Burma (Biswas, 1936, 123); in *Gloeotrichia raciborskii* colonies, in a lake at Chingleput, near Madras ( ! ).

Biswas alga is slightly different. — Filaments 4–5 μ broad, 8 μ broad at the base, ending gradually into a fine hair; sheath 0.5–1 μ thick; trichome 3–5 μ broad, cells square, oblong, about 6–8 μ long, 6–9 μ broad with the sheath, intermediate cells 4–9 μ long and 4–5 μ broad with sheath, and 4–9 μ in length and 3–3.5 μ broad without sheath cell contents granular; heterocysts more or less oblong, 6–8 μ in length, 5–9 μ broad; spores adjacent to the heterocysts either single or in pairs, 8-16 μ in length, 7–8 μ in width. This alga recorded a second time also has similar dimension. The filaments of this latter are said to form dense bushy outgrowths radiating outwards.

Germination of the spores was observed by the writer in the Chingleput material when it was subject to cold treatment. The contents of the spore divided into two cells and either or both the daughter cells again divided to produce a three or four celled germlings which still lie enclosed in the parent wall. The spore wall then becomes gelatinized and the germlings emerge out of the spore and the parent sheath. For a long time the bases of the germlings remain inside the spore-wall.

### 5. **Calothrix wembaerensis** Hieron. et Schmidle

Kirchner, Schizophyceae in Engler and Prantl, Natürlichen Pflanzenfam., I, 1a; 87, fig. 59c, 1898; Forti in De Toni, Sylloge Algarum, 5; 628, 1907;

Frémy, Myxo. d'Afr. équat. franc., 264, 1929; Geitler, Kryptogamenflora, 615, 1932.

Pl. 107, Fig. 3 & Pl. 110, Figs. 1–7

Filaments branched, caespitose, up to 30 μ broad, up to 1 mm long, sheath thick, colorless, gelatinous; cells at the base of filament about 8 μ broad, barrel-shaped often also ½–1½ times as long as broad; heterocysts basal, mostly two, rarely solitary; spores 1–4, cylindrical, with rounded ends, separated from each other by heterocysts, when unripe 10–12–16 μ broad.

Among other algae in a pond, Madras ( ! ).

The dimensions of the Madras alga are, filaments 10.5–14 μ broad, trichome 5.2–7.9 μ broad, spores 9.2–13.1 μ broad and 45–57.9 μ long.

The sheath is firm and thick and the branching in the alga resembles those seen in *Calothrix pilosa* (Poljansky, Jardin Bot. princi. de l'URSS, 27(3): 336–339, 1925).

### 6. **Calothrix bharadwajae** De Toni, J.

Diagnoses Algarum novarum, I, Cent. 6: 501, 1939.

= *Calothrix fritschii* Bharadwaja, The Myxophyceae of the United Provinces-I, Proc. Indian Acad. Sci., B, 2: 100, fig. 3G–J, 1935. (*non* De Toni, 1934 = *Calothrix gracilis* Fritsch, 1912).

Pl. 112, Fig. 3

Filaments generally in groups of 3–7, straight or slightly bent, up to 420 μ long; sheath very distinct, thin, hyaline, closely depressed to the trichome; trichome constricted at the joints, and tapering into a long hair, the terminal portion of the hair without sheath, up to 6.3 μ broad, septa distinct; cells barrel-shaped as long as broad or slightly longer (or sometimes slightly shorter than broad); cells of the hair very much elongated and almost rectangular; heterocysts 4.2–6.3 μ broad, basal and intercalary, basal heterocysts single, spherical or sub-spherical, intercalary heterocysts single or in pairs, spherical, quadratic, or cylindrical, adjoining the basal spore or occasionally separated from it by a short disintegrated cell; spores single adjoining the basal heterocyst, cylindrical or sometimes somewhat conical, with rounded end walls, outer wall smooth, and hyaline, 6.3–8.4 μ broad and 21–42 μ long.

On dead leaves in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

### 7. **Calothrix ghosei** Bharadwaja

The Myxophyceae of the United Provinces, I, Proc. Indian Acad. Sci., B, 2: 99, fig. 3C-F, 1935.

Pl. 112, Fig. 2

Filaments in groups, straight or slightly bent, up to 250 μ long, 7.3–13.7 μ broad; sheath very distinct, thin, hyaline; trichomes 6.3–8.4 μ broad, slightly constricted at the cross walls, apical cell either sharply pointed or rounded; cells quadratic or barrel shaped, slightly longer or shorter than broad; heterocysts single, basal, almost spherical or slightly broader than long, 4.2–6.3 μ broad, enclosed in a sheath; spores single, adjoining the basal heterocyst, cylindrical with rounded ends, 10.5–12.5 μ broad and 31.5–52.5 μ long.

On *Chara* in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

### 8. **Calothrix stellaris** Bornet et Flahault

Revision des Nostocacées hétérocystées, 365, 1886; Forti in De Toni, Sylloge Algarum, 5: 619, 1907; Geitler, Kryptogamenflora, 610, 1932.

Pl. 108, Figs. 4, 5

Filaments single, seldom in groups, unbranched or sparsely branched, straight or bent, 10–12 μ broad, swollen at the base and 15 μ broad; trichomes ending in a thin hair; sheath lamellated, laciniated, colorless; cells 6–7 μ broad, septa more or less ditinct, mostly very slightly constricted, ½ as long as broad, blue green; heterocysts basal, hemispherical, single or 2–3 together, as broad as the cells.

On *Chara* growing in a laboratory tub, Madras ( ! ).

### 9. **Calothrix fusca** (Kütz.) Bornet et Flahault

Revision des Nostocacées hétérocystées, 364, 1886; Forti in De Toni, Sylloge Algarum, 5: 617, 1907; Frémy, Myxo. d'Afr. équat. franc., 249, fig. 222, 1929; Geitler, Kryptogamenflora, 610, fig. 384, 1932; Frémy, Cyano. cotes d'Eur., 145, pl. 3b, fig. 2, 1933.

= *Mastichothrix aeruginea* Kütz., Phyc. generalis, 232, 1843.

Pl. 107, Fig. 10

Filaments single, seldom gregarious, in the gelatinous thallus of other algae, 200–300 μ high, 10–12 μ broad, bent at the base and inflated, up to 15 μ broad, at the base; sheath broad, colourless, at the apices diffluent; trichome 7–8 μ broad, ending in a long thin hair; cells often discoid shorter than broad; heterocysts basal, hemispherical, single or double, smaller than the basal cell of the trichome.

On dead trees and in the mucilage of other algae in stagnant and running waters.—Yenay-eng, Pegu and Rangoon, in Burma (Zeller, 1873a, 181 1873b, 172; Theobald, 1883, 22; Skuja, 1949, 22); Matheran near Bombay (Schmidle, 1900b, 161), River Ravi in Chamba (Singh, V. P., 1941, 251), Shembaganur in Madras State (Frémy, 1942, 22) in India; Perediniya in Ceylon (West and West, 1902, 200).

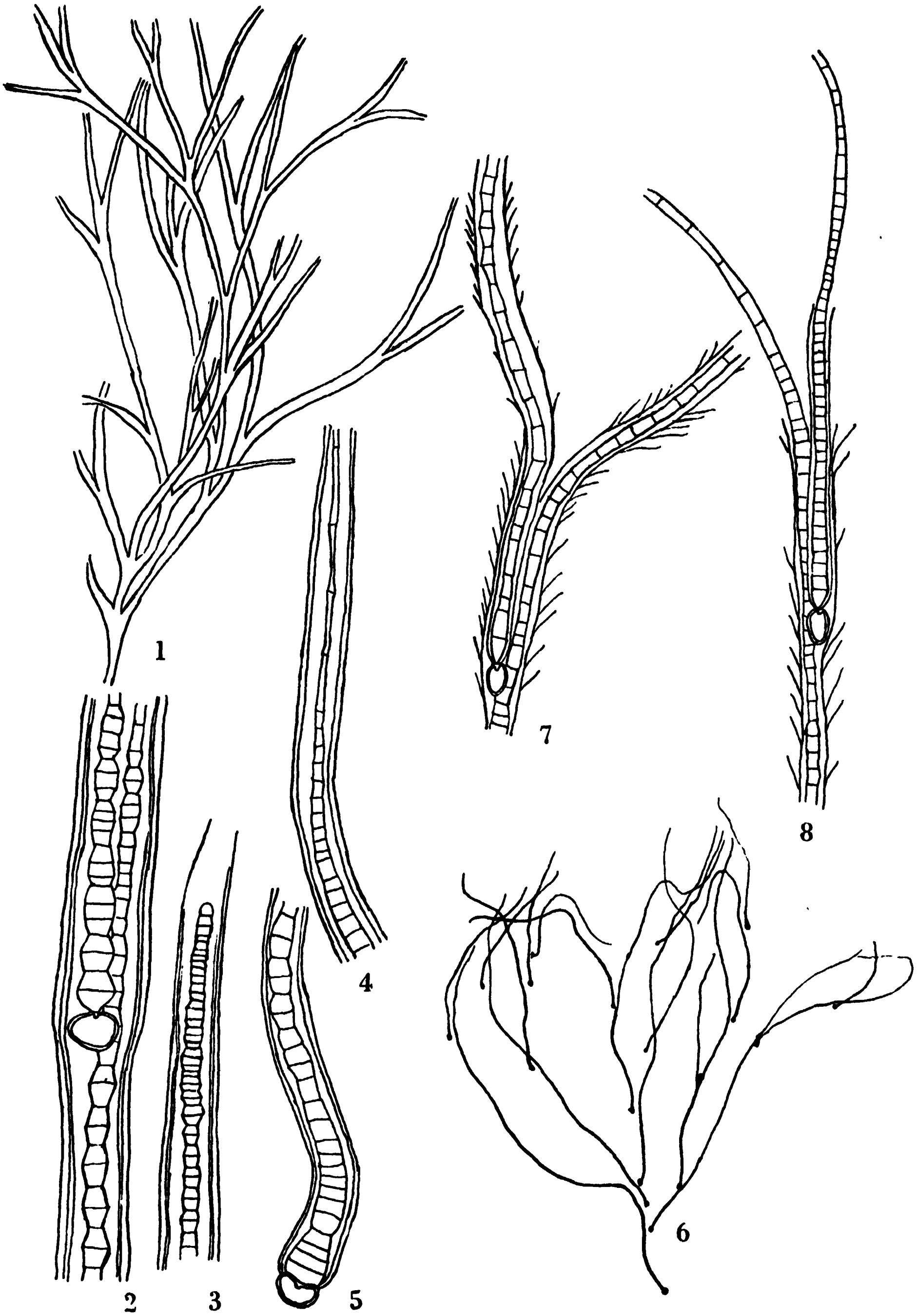

PLATE 108, Figs. 1–8.

1–3. *Dichothrix fusca* Fritsch; 4–5. *Calothrix stellaris* Born. et Flah.; 6–8. *Calothrix parietina* (Näg.) Thuret. (all orig.).

Rao, C. B. (The Myxophyceae of the Orissa Province, Proc. Indian Acad. Sci., B, 8: 159, fig. 1, A, B, 1938b) describes a form.

Pl. 113, Figs. 5, 6

Filaments densely entangled, arranged in groups, 9–14.8 μ broad, at the top up to 4 μ broad, up to 350 μ long; sheath up to 3 μ thick; trichome 5.4–8.5 (–11.1) μ broad, higher up 3–6 μ broad and 0.7–1 μ broad at the apex; cells 2–8 μ long; heterocysts 5.4–8 μ broad, and 3.7–5.4 (7.4) μ long.

On stones in a pond, Berhampur (Rao, C. B., *loc. cit.*).

### Var. **crassa** Rao, C. S.

The Myxophyceae of the Bihar Province I, Proc. Indian Acad. Sci., B, 9: 145, fig. 1 B-E, 1939.

Pl. 113, Figs. 7, 8, 10

Filaments single, irregularly bent or straight, up to 900 μ long, 16–18 μ broad; sheath yellowish brown, stratified, closely adpressed to the trichome; trichomes at the base 10–12 μ broad, higher up 4–6 μ, at the apex 2 μ broad, not constricted at the cross walls, and tapering into a long hair the terminal portion of which is devoid of a sheath; cells 3–6 μ long; heterocysts basal single, hemispherical, 10 μ broad and 6–8 μ long.

In a pond, Dharbhanga (Rao, C. S., *loc. cit.*).

### Var. **minor** Wille

Trichome up to 12 μ broad at the base, above 5.5–6 μ broad; cells 5–5.5 μ long.

In the mucilage of *Anabaena variabilis* in rainwater accumulated in a flower pot, Calcutta (Banerji, 1938, 96).

## 10. **Calothrix castellii** (Massal.) Born. et Flah.

Revision des Nostocacées hétérocystées, 369, 1886; Forti in De Toni, Sylloge Algarum, 5: 627, 1907; Frémy, Myxo. d'Afr. équat. franc., 255, fig. 227, 1929; Geitler, Kryptogamenflora, 611, fig. 385, 1932.

Pl. 114, Fig. 7

Thallus spongy, cushion shaped, widely expanded, dull blue green, surface pubescent by projecting ends of filaments; filaments bent, erect, densely aggregated, 12–13 μ broad, swollen at the base and prostrate, 4–8 mm long; sheath thin close to the trichome, firm, uniform, hyaline, or yellowish; trichome 8–10 μ broad, attenuated into a long hair; cells ½–½ as long as broad; heterocysts basal.

Type not recorded.

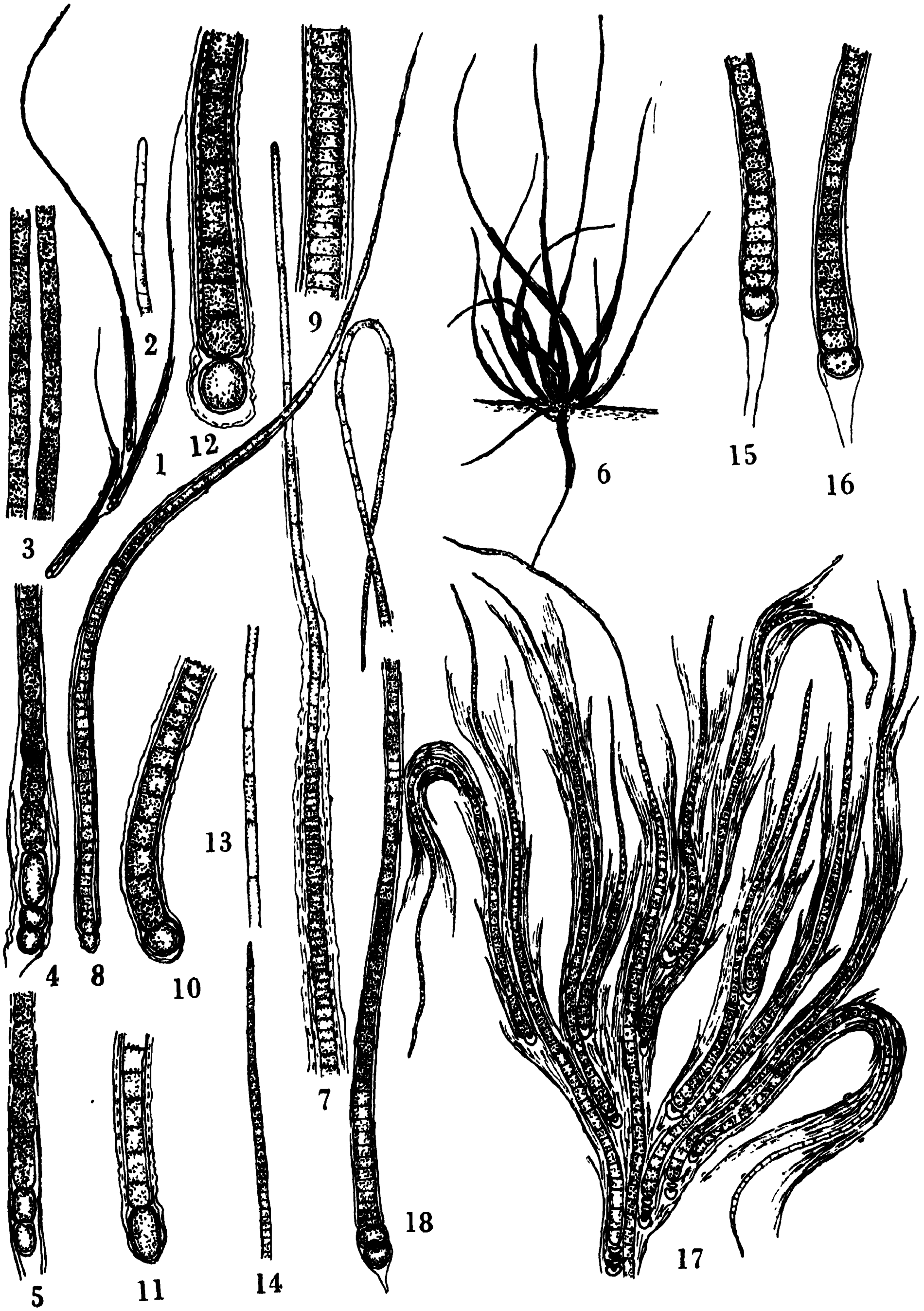

PLATE 109, Figs. 1–18.

1–5. *Calothrix dolichomeres* Skuja (after Skuja); 6–12. *C. geitonos* Skuja (after Skuja); 13–16, 18. *C. gloeocola* Skuja (after Skuja); 17. *Rivularia manginii* Frémy (after Frémy).

Var. **somastipurense** Rao, C. S.

The Myxophyceae of the Bihar Province I, Proc. Indian Acad. Sci., B, 9: 145, fig. 1 F-I, 1939.

Pl. 113, Figs. 11–14

Filaments closely interwoven, 10–20 μ broad, up to 1100 μ long; sheath colourless, unstratified, up to 4 μ thick; trichomes swollen at the base, slightly constricted at the septa and tapering in to a long hair, up to 14 μ broad at the base, higher up 6.6 μ broad, at the apex 2 μ broad; cells 3–8 μ long at the base, higher up 4–6 μ and in the hair 4–12 μ long; heterocysts basal, single, occasionally in pairs, hemispherical, with slightly drawn out apices, 6–12 μ broad and 4–10 μ long.

On a cement floor near water tap, Somastipur in Bihar (Rao, C. S., *loc. cit.*).

### 11. **Calothrix clavatoides** Ghose

On some Myxophyceae from Maymyo, J. Burma Res. Soc., 17(3): 253, pl. 4, fig. 3, 1927d; Geitler, Kryptogamenflora, 621, fig. 394, 1932.

Pl. 113, Fig. 9

Trichome single or in small groups up to 200 μ long, straight or curved, swollen at the base, and about 14 μ broad; sheath narrow, thin, colourless; cells at the base discoid, 10–13 μ thick, in the middle 2–3 times as long as broad, 3–4 μ in diam.; heterocysts basal, single, globose.

In a pond, Maymyo island, Burma (Ghose, *loc. cit.*).

### 12. **Calothrix elenkinii** Kossinskaja

Not. Syst. Crypt. Inst. Horti Bot. Petropol., 3: 11, 1924, Geitler, Kryptogamenflora, 609, fig. 383 (5–6), 1932.

Pl. 114, Figs. 5, 6, 11

Filaments 80–250 μ long, united in tufts, bent at the base, interlaced with each other, swollen at the base, and 6–9 μ broad, in the middle 4.5–6 μ broad; sheath close to the trichome, thin, not lamellated, colourless, open at the ends; trichomes blue or olive green, at the base 5–7 μ broad, in the middle 3.5–4.5 μ broad, not constricted at the base, apical hair not formed; cells quadrate or somewhat shorter than; heterocysts basal, single 4.5–7 μ broad.

On submerged rocks, Vallayani, Travancore (Parukutty, 1940, 118).

Rao, C. B. (The Myxophyceae of the Madras Presidency, J. Indian bot. Soc., 17: 84, 1938a) describes a form.

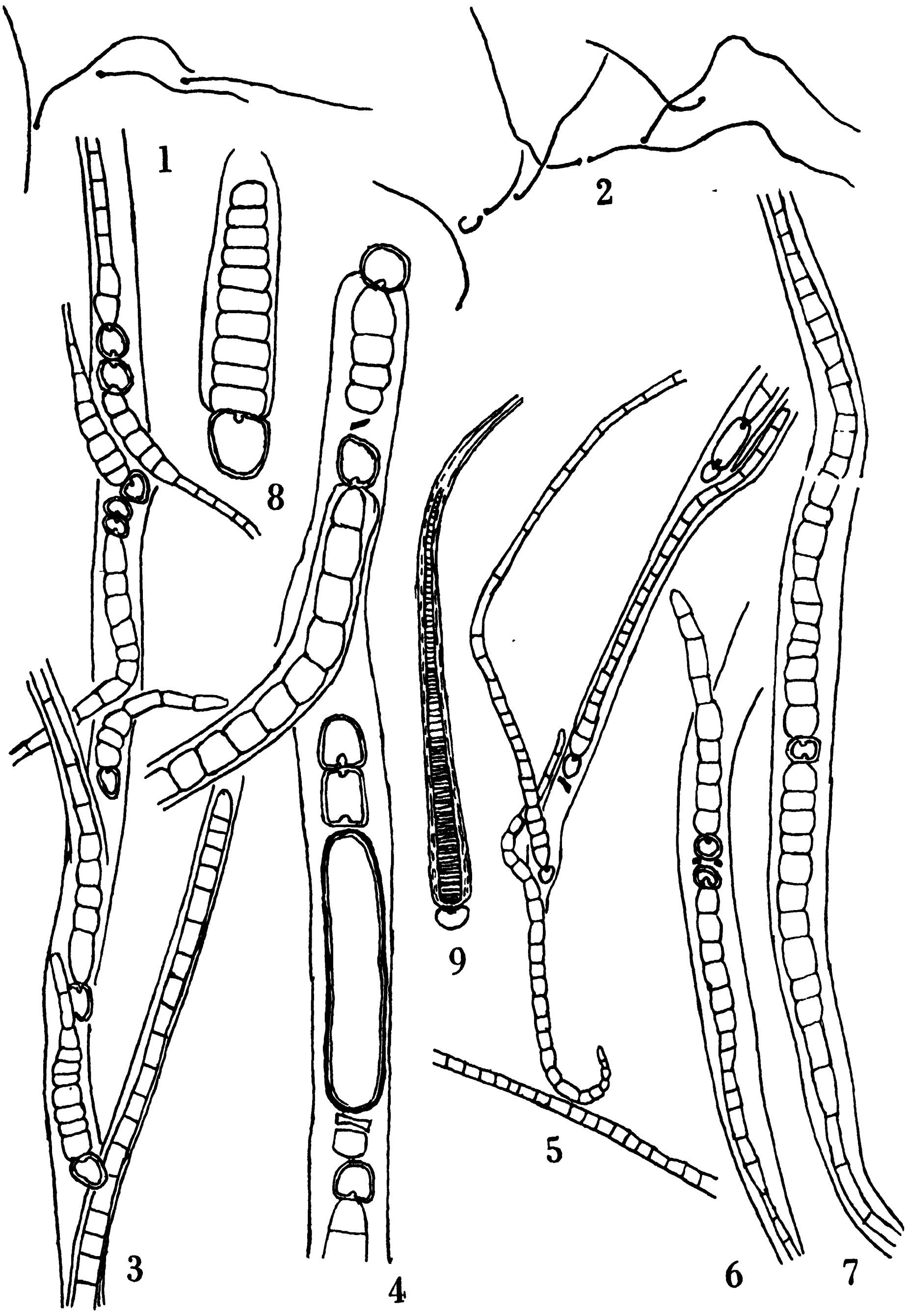

PLATE 110, Figs. 1–9.

1–7. *Calothrix wembaerensis* Hieron. et Schmidle (Orig.); 8. *C. brevissima* West, G. S. (orig.); 9. *C. breviarticulata* West et West (after Frémy).

Filaments 9.6–11.2 μ broad at the base, at the tip 6.6–8 μ broad; sheath up to 1.6 μ thick; trichome at the base 4.8–8.8 μ broad; at apex 3–4 μ broad; cells 1.6–4.8 μ long; heterocysts 4.8–7.2 μ broad.

On floating moist wood in a pond, Polamur, in Andhra (Rao, C. B. *loc. cit.*).

### 13. **Calothrix brevissima** West, G. S.

Freshwater Alg. Tanganyika, J. Linn. Soc. Bot., Lond., 38: 180, pl. 10, fig. 8, 1907; Geitler, Kryptogamenflora, 624, fig. 396, 1932.

Pl. 114, Fig. 1

Filaments epiphytic, many together, very short, 53–94 μ long, 5–7 μ broad, not at all or very little attenuated; sheath firm, close to the trichome, thin, nearly cylindrical, colourless; trichomes very short, 30–62 μ long, little attenuated, with rounded end cells, not constricted at the cross-walls, olive green; cells at the base nearly as long as broad; heterocysts basal, single, seldom many, rounded, hemispherical or subspherical.

Epiphytic on *Hydrodictyon reticulum, Lyngbya gracilis* and *L. majuscula* var. *chakaiense* in ponds and pools, Benaras and Numdur (Rao, C. B., 1937b, 350; 1938a, 84).

### Var. **moniliforme** Ghose orth. mut. Geitler

Myxophyceae of Rangoon, III, J. Burma Res. Soc., 17: 242, pl. 2, fig. 13, 1927b; Geitler, Kryptogamenflora, 624, 1932.

Pl. 112 Fig. 8

Filaments gregarious, 5–7 μ broad, not at all or very little attenuated; sheath indistinct, narrow, colourless; trichomes pale olive green, very short, 30–62 μ long, with rounded end cells, moniliform; cells at the base as long as broad or shorter, globose or depressed globose, 4–5 μ broad.

In laboratory cultures, Rangoon (Ghose, *loc. cit.*); epiphytic on *Lyngbya majuscula* floating in masses in a stream near Tirupati ( ! ).

### 14. **Calothrix thermalis** (Schwabe) Hansg.

Beitrage zur kenntnis der böhmisch Thermalalgenflora, Österr. bot. Z., 34: 279, 1884; Bornet and Flahault, Revision des Nostocacées hétérocystées, 368, 1886; Forti in De Toni, Sylloge Algarum, 5: 625, 1907; Frémy, Myxo. d'Afr. équat. franc., 262, fig. 236, 1929; Geitler, Kryptogamenflora, 610, 1932.

Pl. 112, Figs. 9–13 & Pl. 114, Figs. 8–10

Thallus expanded, mucilaginous, soft, blue-green or olive-green; filaments intricate, flexuous, up to 3 mm long; densely arranged, 8–10 μ broad, swollen

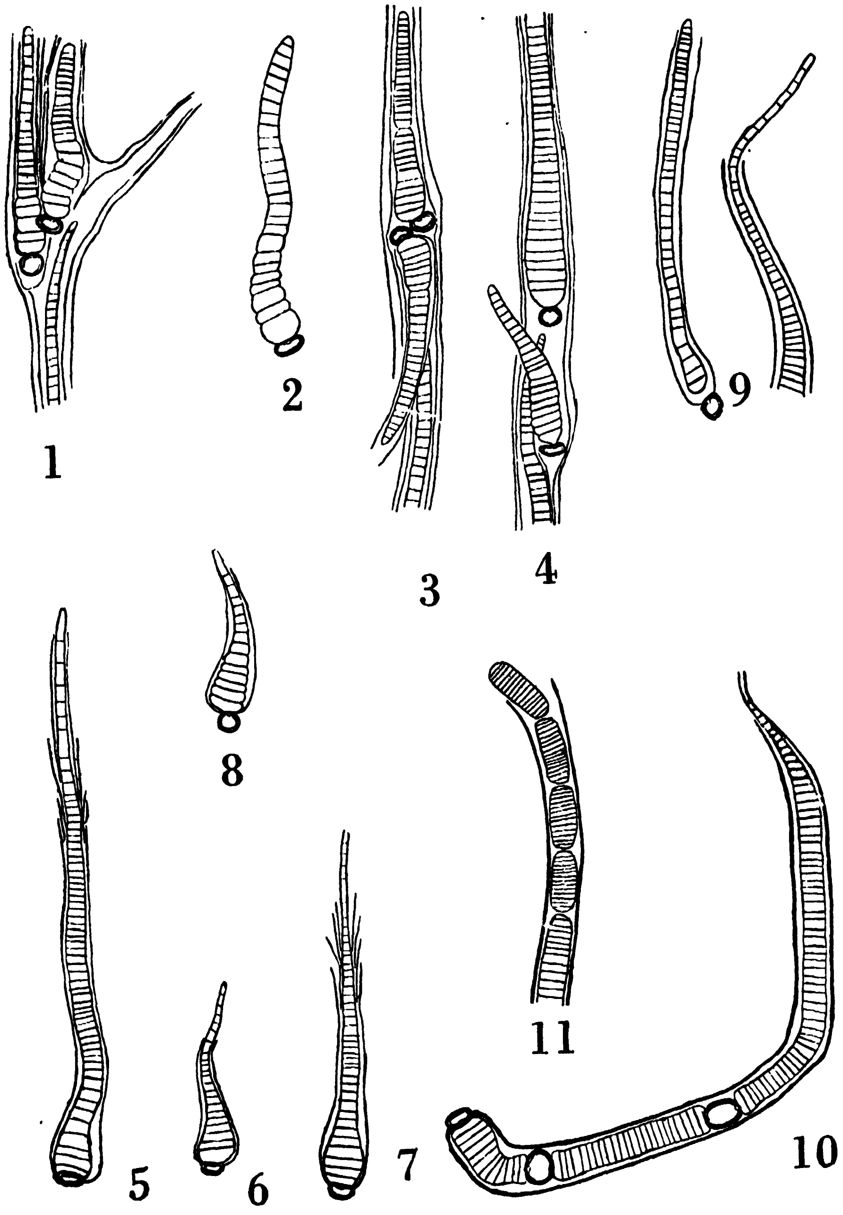

PLATE 111, Figs. 1–11.

1, 3, 4. *Dichothrix baueriana* (Grun.) Born. et Flah.; 2, 5–8. *Calothrix contarenii* (Zanard.) Born. et Flah.; 9. *C. scopulorum* (W. & M.) Ag.; 10–11. *C. crustacea* Thuret (all after Iyengar & Desikachary).

at the base; sheath thick, homogeneous, hyaline or yellowish at the base, unlamellated; cells 5–8 μ broad, ⅓ to as long as broad, seldom longer, blue-green; heterocysts basal, rarely intercalary, ellipsoidal to subspherical.

On cement walls of drain, in Rangoon and Mergui islands (Ghose, 1927a, 224; 1927c, 247; 1927e, 83).

### 15. **Calothrix gardneri** J. De Toni

Not. nomencl. Algol., 1: 6, 1934.

= *Calothrix linearis* Gardner, New Myxophyceae from Porto Rico, Mem. N. Y. Bot. Gdn. 7: 68, pl. 13, fig. 21, 1927; Geitler, Kryptogamenflora, 623, fig. 395d, 1932. *non* Gardner, 1926.

Pl. 115, Fig. 5

Filaments erect, for the major part straight, 350–500 (–1000) μ long, cylindrical, but swollen at the base and attenuated at the apex, mostly in the lower portions branched; sheath 2–2.5 μ thick, somewhat slimy, colourless, not lamellated; trichome cylindrical, 5–7 μ broad, in the basal part constricted at the cross-walls, ending in a short hair; cells quadrate to ½ as long as broad; heterocysts basal, mostly hemispherical.

Type not recorded.

Rao, C. B. (The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 350, 1937b.) describes a form.

Filaments 10–12 μ broad at the base, at the top 4–5 μ broad; trichomes up to 450 μ long, 6.6–9.5 μ broad at the base, at the top 3–3.3 μ broad; cells 2.5–5 μ long; heterocysts 6.6–8 μ broad and 5–7 μ long.

On the plinth of a building near the outlet of a drain, Benaras (Rao, C. B., *loc. cit.*).

### 16. **Calothrix braunii** (A. Br.) Bornet et Flahault

Revision des Nostocacées hétérocystées, 368, 1886; Forti in De Toni, Sylloge Algarum, 5: 624, 1907; Frémy, Myxo. d'Afr. équat. franc., 257, fig. 230, 1929; Geitler, Kryptogamenflora, 606, fig. 381, 1932.

Pl. 114, Fig. 3

Thallus caespitose, blue green or brownish; filaments straight, parallel, 500 μ long, 9–10 μ broad, swollen at the base, slightly bent; sheath thin, close to the trichome, colourless; trichome 6–7 μ broad, ending in a long hair, constricted at the cross-walls; cells somewhat shorter than broad; heterocysts basal, hemispherical.

In rice fields, Faridpur, Bengal (Banerji, 1935, 298; 1938, 95).

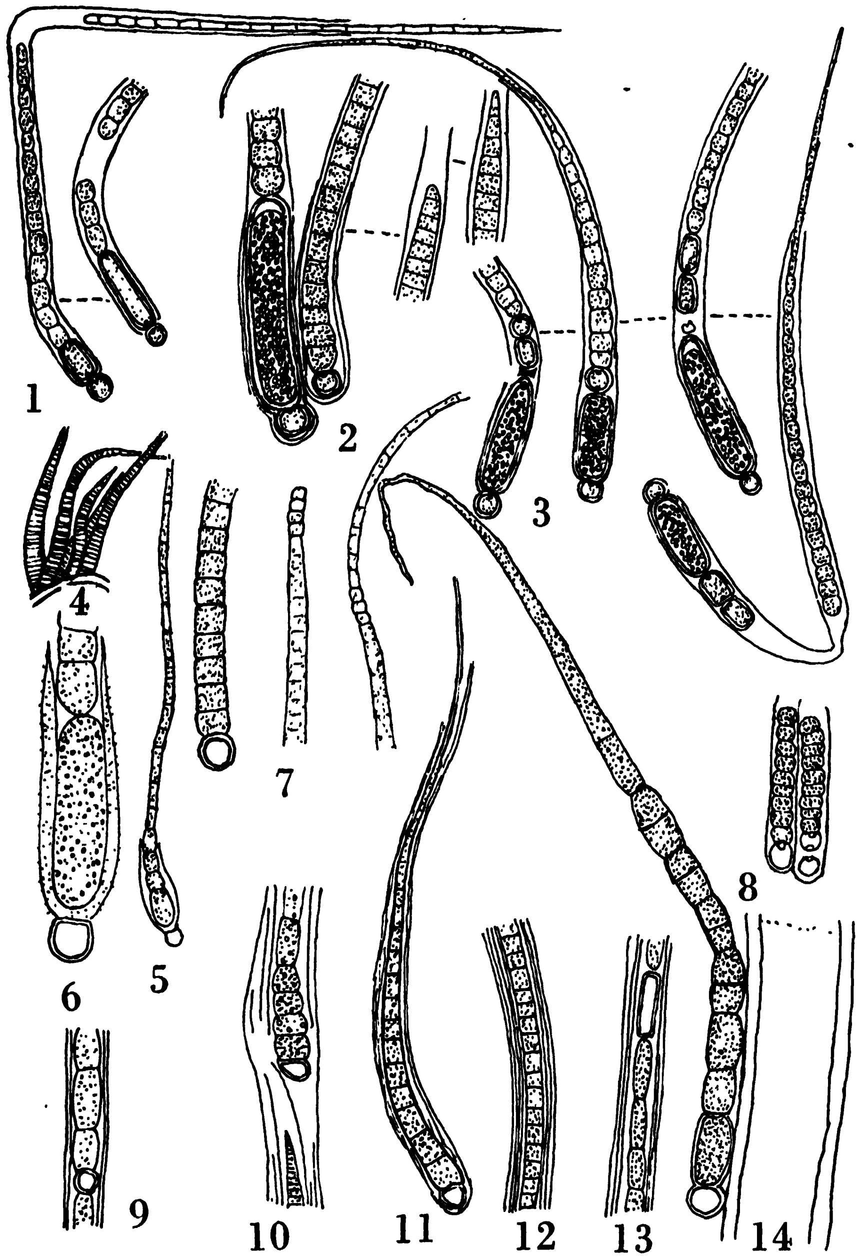

PLATE 112, Figs. 1–14.

1. *Calothrix scytonemicola* Tilden forma (after Bharadwaja); 2. *C. ghosei* Bharadwaja (after Bharadwaja); 3. *C. bharadwajae* De Toni (after Bharadwaja); 4. *Homoeothrix hansgirgi* (Schmidle) Lemm. (after Schmidle); 5, 6. *Gloeotrichia indica* Schmidle (after Schmidle); 7. *Rivularia hansgirgi* Schmidle (after Schmidle); 8. *C. brevissima* v. *moniliforme* Ghose (after Ghose); 9–13. *Calothrix thermalis* (Schmidle) Hansg. (after Tilden); 14. *C. scytonemicola* Tilden (after Tilden).

17. **Calothrix geitonos** Skuja

Zur Süsswasseralgenflora Burmas, 26, pl. 2, figs. 7–13, 1949.

Pl. 109, Figs. 6–12

Filaments aggregated in a caespitose colony, rarely solitary, erect or flexuous, about 1 mm long, gradually attenuated into a long hyaline hair, base not dilated, but appears dilated by the broadening of the sheath; sheath colourless, sometimes mucilaginous, about 3 μ thick, partly lamellated, persistent, at the upper ends diffluent; cells at the base 7–8 μ broad, 1–1½ times as long as broad, distinctly constricted at the cross-walls, cells in the hair many times longer than broad, olivaceous or blue-green; heterocysts 1–3, basal, rounded cylindrical, barrel-shaped or hemispherical, 8–9.5 μ broad and 7–19 μ long, yellowish.

On grass blades, Royal lakes, Rangoon, Burma (Skuja, *loc. cit.*).

18. **Calothrix scytonemicola** Tilden

Minnesota algae, 1: 265, pl. 17, fig. 7, 1910; Geitler, Kryptogamenflora, 627, fig. 398, 1932.

Pl. 112, Fig. 14

Filaments 7–8 μ in diam., isolated or in small groups, the lower portion attached to the host, the remainder free and erect, ending in a pointed hair; sheath not distinct; heterocysts 8 μ in diam., basal, usually two in number, somewhat globose.

On submerged aquatic plants in pools and ponds.—Rangoon in Burma, (Ghose, 1927b, 242); Borivli near Bombay (Gonzalves and Joshi, 1943a, 37).

Ghose gives the breadth of the heterocyst as 6–8 μ.

Bharadwaja (Myxophyceae of the United Provinces, I, Proc. Indian Acad. Sci. B, 2: 98, fig. 3A, B, 1935) describes a form.

Pl. 112, Fig. 1

Filaments up to 350 μ long; sheath distinct; trichome up to 6.3 μ broad; heterocysts basal in pairs, terminal ones 4.2–6.3 μ diam., sub-terminal one 4.2–7.3 μ broad and 9.4–21 μ long.

On *Aulosira* etc., growing on dead leaves in a stagnant pond, Benaras (Bharadwaja, *loc. cit.*).

19. **Calothrix breviarticulata** W. et G. S. West

Welwitsch's Afric. Algae., J. Bot. Lond., 35: 240, 1897; Forti in De Toni, Sylloge Algarum, 5: 620, 1907; Frémy, Myxo. d'Afr. équat. franc., 249, fig. 223, 1929; Geitler, Kryptogamenflora, 616, fig. 389, 1932.

Pl. 110, Fig. 9

Filaments single or many together, at the base 15–16 μ broad, in the middle 11.5–12.5 μ broad, up to 380 μ long, gradually attenuated at the apex; sheath thick, lamellated, blackish brown; trichome at the base 8.5 μ broad, in the middle 5.5–7.5 μ broad, constricted at the septa; cells very short, discoid, ¼–½ times as long as broad, pale blue green; heterocysts basal single, hemispherical.

On *Plectonema wollei* in an artificial tank, Perediniya, Ceylon (West & West, 1902, 200).

### 20. **Calothrix viguieri** Frémy

Myxo. d'Afr. équat. franc., 252, fig. 226, 1929; Geitler, Kryptogamenflora, 617, fig. 390, 1932.

Pl. 107, Fig. 12

Thallus irregular, thin, flake like, maculiform, grey-green, calcium incrusted, up to 1 cm big or diam.; filaments more or less entangled, nearly straight, falcate, or bent, 150–200 (–300) μ long, slightly broader at the base, above sub-cylindrical, and 15 (–20) μ broad, gradually attenuated; sheath thin, firm, colourless, papyraceous, irregularly lamellated, outside slightly lacerated, produced above beyond the tip of the trichome; trichome 10 (–15) μ broad above the base, gradually attenuated, no hair found produced outside the sheath, cells in the middle of the trichome $^1/_3$–$^1/_5$ times as long as broad, seldom up to ½ as long, not at all or a little constricted at the cross-walls; heterocysts basal, single, hemispherical or compressed.

Type not recorded.

Rao, C. B. (The Myxophyceae of the Madras Presidency—I, J. Indian bot. Soc., 17: 84, 1938a) describes a form.

Filaments 10–22 μ broad at the base, at the top 6.6–10 μ broad; trichome 10–16 μ broad, at the top 2.5–5.5 μ broad; cells 3–10 μ long at the base, at the tip 28–50 μ long, cross-walls with granules; heterocysts 8–16 μ broad, 5–11 μ long, basal, enclosed by the sheath.

In a roadside pond, Polamur, Andhra.

### 21. **Calothrix parietina** Thuret ex Born. et Flah.

Thuret, Essai class. Nostochinées, Ann. Sci. nat. Bot., ser. 6, 1: 381, 1875; Bornet and Flahault, Revision des Nostocacées hétérocystées, 366, 1886; Forti in De Toni, Sylloge Algarum, 5: 62, 1907; Frémy, Myxo. d'Afr. équat. franc., 259, fig. 232, 1929; Geitler, Kryptogamenflora, 604, fig. 380, 1932; Frémy, Cyano. cotes d'Eur., 144, pl. 37, 1933.

= *Mastichonema caespitosum* Kütz., Phyc. germ., 184, 1845.

Pl. 108, Figs. 6–8 & Pl. 115, Fig. 1

Filaments single or forming an expanded crustaceous thallus, thallus brownish to dark black in colour, sometimes somewhat with calcium incrustation; filaments 0.25 mm to 1 mm high, mostly branched, closely adpressed,

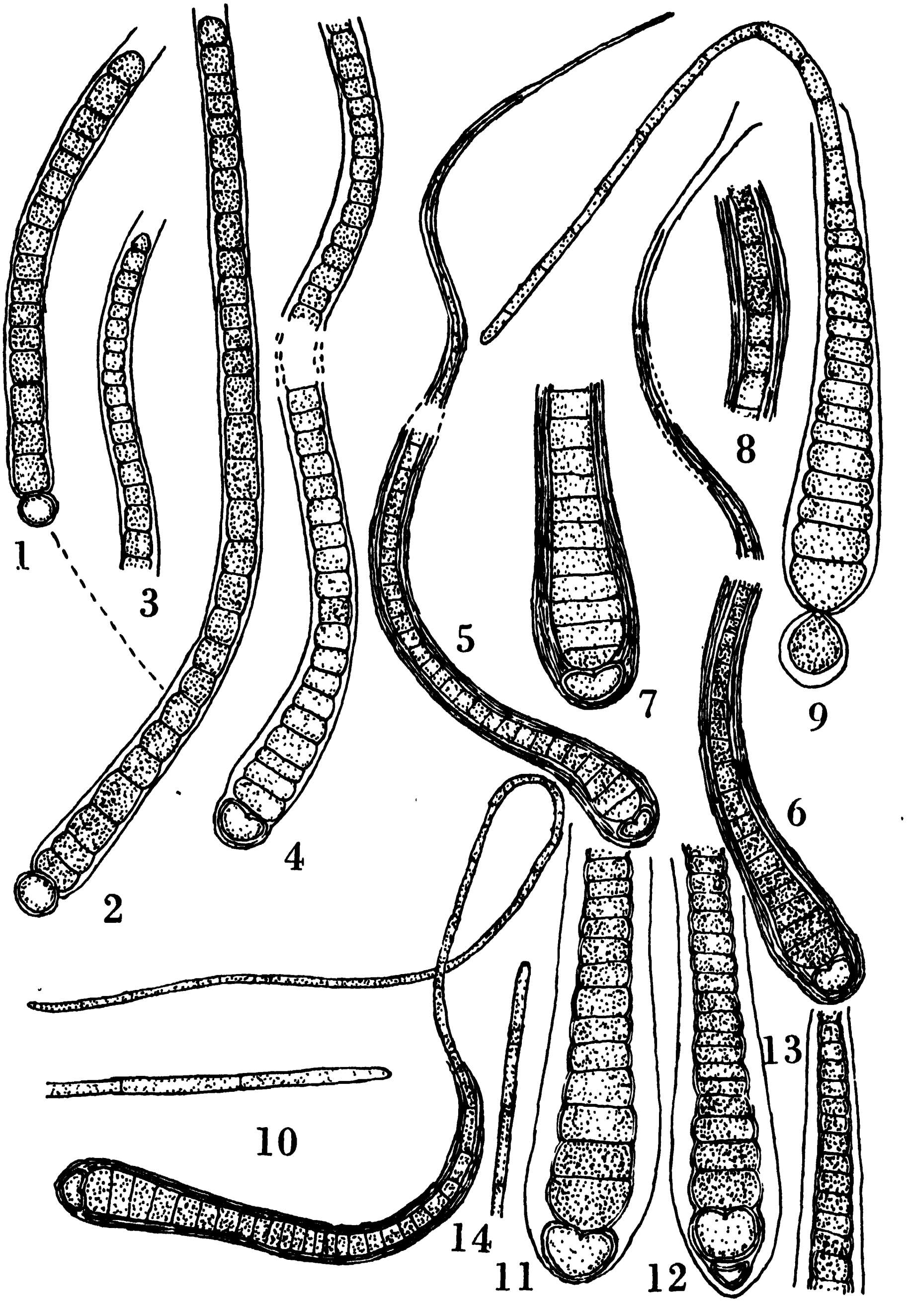

PLATE 113, Figs. 1–14.

1–2. *Calothrix marchica* v. *intermedia* Rao, C. B. (after Rao, C. B.); 3, 4. *Calothrix marchica* v. *crassa* Rao, C. B. (after Rao, C. B.); 5, 6. *C. fusca* (Kütz.) Born. et Flah. forma (after Rao, C. B.); 7, 8, 10. *C. fusca* v. *crassa* Rao, C. B. (after Rao, C. B.); 9. *C. clavatoides* Ghose (after Ghose); 11–14. *C. castellii* v. *somastipurense* Rao, C. S. (after Rao, C. S.).

erect or seldom horizontal, 10–12 (seldom up to 18 μ) μ broad; sheath very close, generally lamellate, sometimes homogeneous; trichomes 5–10 μ broad, produced into a hair, hair 1 μ broad; cells at the base shorter than broad, mostly 1½–3 times as long as broad, blue-green; heterocysts basal or also rarely intercalary, hemispherical, broader than the cells; hormogones about 3 times as long as broad, single or a few one behind the other.

On submerged plant parts and on other algae etc., — Calcutta (Martens, 1870, 258; Prain, 1905, 335); Shembaganur in Madras State (Frémy, 1942, 22), On *Urococcus tropicus,* Akyab, and Kangyi in Burma (Zeller, 1873a, 181; Theobald, 1883, 22; West and West, 1907, 241); Lahore in Pakistan (Ghose, 1924, 345); also on wet rocks near Gundar falls, Kodaikanal ( ! ).

The trichomes in the Kodaikanal material are 3.9–7.9 μ broad below and the heterocysts 5.2–9.2 μ broad and 7.0–10.5 μ long.

### 22. **Calothrix dolichomeres** Skuja

Zur Süsswasseralgenflora Burmas, 25, pl. 2, figs. 1–6, 1949.

Pl. 109, Figs. 1–5

Filaments false branched, erect, more or less arched and flexuous, about 1 mm long, aggregated in caespitose colonies gradually attenuated into a long hyaline hair, base not dilated, but appears dilated by the broadening of the sheath; sheath colourless sometimes mucilaginous, about 3 μ thick, partly lamellated, persistent, at the upper ends diffluent; cells at the base 7–8 μ broad, 1–2½ times as long as broad, distinctly constricted at the cross-walls, cells in the hair many times longer than broad, olivaceous or blue-green; heterocysts 1–3, basal, rounded cylindrical, barrel-shaped or hemispherical, 8–9.5 μ broad and 7–19 μ long, yellowish.

On grass blades, Royal lakes, Rangoon (Skuja, 1949, 25).

### 23. **Calothrix weberi** Schmidle

Einig. Alg. aus Pruess. Hochmoor, Hedwigia, 38: 173, 1899; Forti in De Toni, Sylloge Algarum 5: 625, 1907; Geitler, Kryptogamenflora, 606, 1932.

Filaments single, free floating or attached, unbranched, very much bent, often irregularly spirally coiled, rarely straight; about 8 μ broad at the base, ending in a hair, 2–2.5 μ broad; sheath diffluent, hyaline, thin close to the trichome; trichome 5.1 μ broad; cells cylindrical, a little longer than broad, blue-green; heterocysts basal.

In tank Basawakulam, Ceylon (Crow, 1923b, 143).

Crow suspects that this might be a stage of a *Rivularia.*

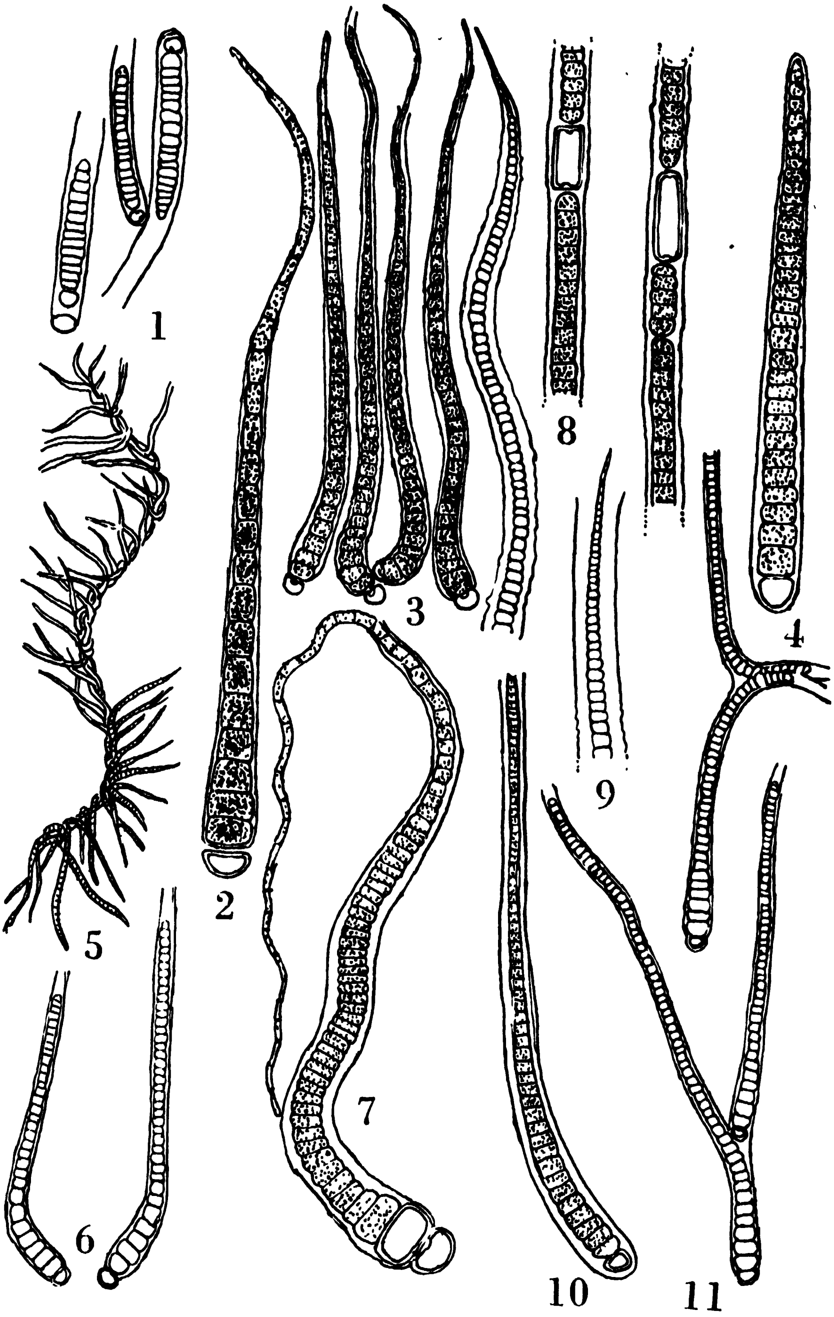

PLATE 114, Figs. 1–11.

1. *Calothrix brevissima* West, G. S. (after West, G. S.); 2. *C. clavata* West, G. S. (after Frémy); 3. *C. braunii* Born. et Flah. (after Frémy); 4. *C. marchica* Lemm. (after Frémy); 5, 6, 11. *C. elenkinii* Kossink. (after Poljansky); 7. *C. castellii* (Massal.) Born. et Flah. (after Frémy); 8, 9–10. *C. thermalis* Hansg. (after Elenkin).

### 24. **Calothrix membranacea** Schmidle

Beitr. zur Algenfl. Afrikas, Engler's Bot. Jahrb., 30: 61, pl. 2, figs. 12–14, 1901; Forti in De Toni, Sylloge Algarum, 5: 627, 1907; Frémy, Myxo. d'Afr. équat. franc., 262, figs. 235, 1929; Geitler, Kryptogamenflora, 629, 1932.

Pl. 106, Fig. 10

Thallus papery, blue green; filaments long, horizontal, mostly curved, irregularly floccose, rarely branched, gradually attenuated; sheath thin, hyaline, not lamellated; trichomes torulose, only seldom trichome produced into a hair; cells half as long as broad to subquadrate, in the apex and the hair more or less hyaline and elongate; hormogones with a few cells, formed in series; heterocysts present, basal.

In the mucilage of *Nostochopsis lobatus*, Kanuggyi canal, near Rangoon (?), Burma (Skuja, 1949, 28); in cultures of soils from cultivated, or uncultivated soil, Red soils, from Allahabad and Vandalur near Madras (Mitra, 1951, 359/360); in a laboratory culture, Madras ( ! ).

In the Burmese alga the filaments were 10 μ broad. In the Madras alga the filaments were up to 250 μ long, the trichomes 3.9–6.6 μ broad and the heterocysts 3.9–5.2 μ broad.

Skuja gives a complete description in Handel-Mazetti Algae.

Geitler (1932, 629) considers this species the same as *C. intricata*.

### 25. **Calothrix gloeocola** Skuja

Zur Süsswasseralgenflora Burmas, 27, pl. 3, figs. 14–18, 1949.

Pl. 109, Figs. 13–16, 18

Filaments solitary, simple, flexuous, in the mucilage of other algae, gradually attenuated into a moderately long hair, up to 650 μ long, base dilated or clavate; sheath thin, about 1 μ thick, colourless, more or less homogeneous, sometimes diffluent; cells at the base 5–6.5 μ, in the middle about 3 μ broad, or slightly shorter or longer than broad, contents olivaceous or blue green, homogeneous or finely granulated, lower septa granulated; heterocysts basal, solitary or geminate globose or truncate, hemispherical or subovoid, 6–7 μ broad, 7–8 μ long, partly enclosed by the sheath.

In the thallus of *Nostochopsis lobatus* in the Royal lakes, Rangoon, Burma (Skuja, *loc. cit.*).

### 26. **Calothrix clavata** West, G. S.

in Fuhrmann et Mayor, Voyage d'explor. Colombie, 1019, pl. 21, fig. 6–7, 1914; Frémy, Myxo. d'Afr. équat. franc., 257, fig. 229, 1929; Geitler, Kryptogamenflora, 609, fig. 382, b, c, 1932; Frémy, Cyano. cotes d'Eur., 142, pl. 36, fig. 1, 1933.

Pl. 114, Fig. 2

Filaments single, or a few together, up to 100 μ long, straight, or slightly bent, prominently swollen at the base, 7 μ broad; sheath close to the trichome, very thin, colourless; trichomes slightly constricted at the cross walls, 5–5.5 μ broad at the base, in the middle 2–5 μ broad; cells discoid at the base and 2–3 times as long as broad above; heterocysts basal, single hemispherical.

Kanuggyi canal, Burma (Skuja, 1949, 25).

### 27. **Calothrix epiphytica** W. et G. S. West

J. Bot. Lond., 35: 290, 1897; Forti in De Toni, Sylloge Algarum, 5: 621, 1907; Frémy, Myxo. d'Afr. équat. franc., 252, 1929; Geitler, Kryptogamenflora, 606, 1932.

Filaments single or in groups, up to 250 μ long, seldom up to 350 μ long; at the base 5–7.5 μ broad, at the apex gradually attenuated; sheath somewhat thick, colourless; trichome at the base, 3.5–4 μ broad tapering to a fine hair; cells somewhat shorter than broad below and longer than broad above; heterocysts basal, single, small.

On the shells of *Thaia Intha* of the Inle, Burma (Biswas, 1936, 116), in cultures of paddy-field soil, Goregaon, Bombay (Gonzalves and Gangla, 1949, 54).

### 28. **Calothrix marchica** Lemmermann

Abh. Naturh. Ver. Bremen, 23(1): 248, fig. 1, 2, 1914; Geitler, Kryptogamenflora, 607, fig. 382a, 1932.

Pl. 114, Fig. 4

Filaments straight, or slightly bent, single, at the base 5–6 μ broad, with a close thin colourless sheath; sheath not coloured blue by chlor-zinc-iodide; trichome blue green, gradually attenuated into a hair, distinctly constricted at the cross-walls, at the base 4–5.5 μ broad; cells nearly as long as broad, or ½ to ¼ as long as broad, end cell conical, somewhat pointed; heterocyst single, basal nearly spherical or hemispherical, 4–5.5 μ broad.

Type not recorded.

### Var. **crassa** Rao, C. B.

The Myxophyceae of the United Provinces III, Proc. Indian Acad. Sci., B, 6: 349, fig. 2E, 1937b.

Pl. 113, Figs. 3, 4

Filaments in groups, irregularly bent and closely entangled, 9.6–14.4 μ broad, up to 450 μ long; sheath thin, firm, yellowish, or hyaline; trichomes

8.4–12.8 μ broad, constricted at the septa, ends tapering but without a hair, end cell conical with a rounded apex, sometimes pointed cells quadratic, as well as shorter or longer than broader, 2–3.3 μ long, at the apices up to 4.8 μ long; heterocysts single, basal, spherical or subspherical, 8.2–12.5 μ broad and up to 5 μ long.

On moist wall, Benaras (Rao, C. B., *loc. cit.*) in a tank, at Bandra, near Bombay (Gonzalves and Joshi, 1946, 170).

### Var. **intermedia** Rao, C. B.

The Myxophyceae of the United Provinces III, Proc. Indian Acad. Sci. B, 6: 350, fig. 2, F, G, 1937b.

Pl. 113, Figs. 1, 2

Filaments epiphytic on other algae, placed singly or in groups of two or three, 6–8 μ broad and up to 350 μ long, with slight attenuation, without a terminal hair; sheath thin, firm, hyaline; trichomes 5.8–7.8 μ broad, constricted at the cross walls; cells quadratic, shorter or longer than broad, 3.2–8 μ long, end cells rounded; heterocysts single, basal, usually spherical, 5.6–7.8 μ broad.

In a pond, Benaras (Rao, C. B., *loc. cit.*).

## SPECIES INQUIRENDA

### **Calothrix indica** Montagne, C.

Sixieme Centurie de Plantes Cellulaires nouvelles tant indigénes qu exotiques, Dec. VII Ax., Ann. Sci. nat., Bot., ser. 3, 12: 287, 1849. *non* Crouan.

Filaments many, erect, rigid, yellowish-olivaceous, united in cauliform bundles, fascicles up to 1 mm long, and 2/3–3/5 mm broad; filaments about 15 μ broad, attenuated, obtuse or acuminate, flexuous; cells at the base subquadrate, shorter above, about 1.4 μ long.

On leaves, Assam (Montagne, *loc. cit.*).

## SPECIES DELENDAE

1. *Calothrix anomala* Mitra (Mitra, A. K., 1951, p. 360, *nomen nudum*).
2. *C. membrancacea* var. *purpurea* Mitra (Mitra, A. K., 1951, 362, *nomen nudum*).
3. *C. ramosa* Bharadwaja (Bharadwaja, 1933b, 246, *nomen nudum*).
4. *C. catenata* Mitra (Mitra, A. K., 1951, 362, *nomen nudum*).

## **DICHOTHRIX** Zanardini

Plant. Maris rubri enum., 89, 1858; Bornet and Flahault, Revision des Nostocacées hétérocystées, 376, 1886.

Thallus caespitose, penicillate or cushion like (pulvinate); filaments subdichotomously false branched, at the base of false branches often many trichomes in a common sheath; trichomes generally ending in a hair; heterocysts mostly basal, sometimes intercalary.

Type species: *D. penicillata* Zanard.

Poljansky (in Elenkin, 1949; *see* also Hansgirg, 1892) reduces this genus as a section under *Calothrix* (Ag.) Polj. V. *sensu lat.*

## KEY TO THE SPECIES

1. Sheath at their ends funnel-shaped, not attenuated .......................... 2
1. Sheath at their ends not funnel-shaped, tapering .......................... 3
    2. Filaments 15–18 μ broad ...................... 1. *D. gypsophila* (p. 545)
    2. Filaments 9–13.5 μ broad ...................... 2. *D. compacta* (p. 546)
3. Filaments broader than 15 μ broad ...................... 3. *D. baueriana* (p. 546)
3. Filaments 9–12 μ broad.......................................................... 4
    4. No hair formed .................................. 4. *D. fusca* (p. 546)
    4. Hair present ............................... 5. *D. orsiniana* (p. 548)

### 1. **Dichothrix gypsophila** (Kütz.) Born. et Flah.

Revision des Nostocacées hétérocystées, 377, 1886; Forti in De Toni, Sylloge Algarum, 5: 642, 1907; Frémy, Myxo. d'Afr. équat. franc. fig. 241, 1929; Geitler, Kryptogamenflora, 590, fig. 372, 1932; Frémy, Cyano. cotes d'Eur., 150, pl. 41, fig. 3, 1933.

Pl. 107, Figs. 5, 8, 9

Thallus caespitose or penicillate, expanding, sparse, or in small clumps amidst other algae, often with calcium incrustation; filaments up to 2 mm long, 15–18 μ broad at the ultimate branches, erect, penicillate, false branches adpressed above and included in a common sheath; sheath thick, lamellated, smooth, orange brown, later opaque ocreate and broadened out, lacerated or torn; trichome olive-green, 6–8 μ broad, attenuated to a long hair; cells barrel-shaped, as long as or somewhat longer than broad; heterocysts basal, subspherical, closely compressed or somewhat longer.

Igatpuri near Bombay (Kunze ex De Toni, 1907, 642); rainwater pools, Borivli near Bombay (Gonzalves and Joshi, 1943a, 37); environs of Shembaganur, Madras State (Frémy, 1942, 22).

Poljansky (in Elenkin, 1949) transfers this species to *Calothrix* as *C. gypsophila* (Kütz.) Thur. em. Polj., and includes in it *D. compacta* (Ag.) Born. and Flah., *D. orsiniana* (Kütz.) Born. and Flah., and *D. fusca* Fritsch.

### 2. **Dichothrix compacta** Born. et Flah.

Revision des Nostocacées hétérocystées, 378, 1886; Forti in De Toni, Sylloge Algarum, 5: 643, 1907; Geitler, Kryptogamenflora, 591, 1932.

Pl. 107, Figs. 1, 2

Thallus caespitose, up to 1 mm high, densely aggregated; filaments 9–12 μ broad, erect, penicillate, upper branches adpressed, in a common sheath; sheath lamellated, smooth, yellowish brown, uniform, broadened above and lacerated; trichome 4.2–6 μ broad, with apical hairs; cells as long as broad, or up to ½ as long as broad, pale olive; heterocysts subspherical or longer.

In the environs of Shembaganur, Madras State (Frémy, 1942, 22, 25).

Frémy's alga is much bigger than the type. — Filaments 15–18 μ broad, very rarely 25 μ broad, hairs 6 μ broad.

### 3. **Dichothrix baueriana** (Grun.) Born. et Flah.

Revision des Nostocacées hétérocystées, 375, 1886; Forti in De Toni, Sylloge Algarum, 5: 640, 1907; Geitler, Kryptogamenflora, 586, 1932; Frémy, Cyano. cotes d'Eur., 141, pl. 41, fig. 2, 1933.

Pl. 111, Figs. 1, 3, 4

Thallus caespitose, penicillate, often very much expanded, and up to 1 cm high, green or brown; filaments flexuous, ultimate branches 15–21 μ broad; sheath close to the trichome, gelatinous, soft, uniform, hyaline or yellowish; trichome 5–7.5 μ rarely 9 μ broad, pale blue-green, gradually terminating in a hair, constricted at the cross walls; cells as long or ½ as long as broad; heterocysts basal, subspherical or hemispherical.

Igatpuri and Matheran near Bombay (Schmidle, 1900b, 161; *see* also Forti in De Toni, 1907, 640); growing on the sides of the harbour piers (Iyengar and Desikachary, 1944, 47).

### 4. **Dichothrix fusca** Fritsch, F. E.

Ann. S. Afr. Mus., 9: 581, fig. 38, 1918; Geitler, Kryptogamenflora, 593, 1932.

Pl. 108, Figs. 1-3

Filaments caespitose, up to 750 μ long, attached to rocks; filaments and false branches nearly straight, seldom somewhat bent, 9–12 μ broad; false branches adpressed diverging at the apices; sheath thick, lamellated apices gradually attenuated, colourless or more or less yellow to brown, up to 5 μ thick, at the ends open; trichome 6–9 μ broad, not constricted at the cross

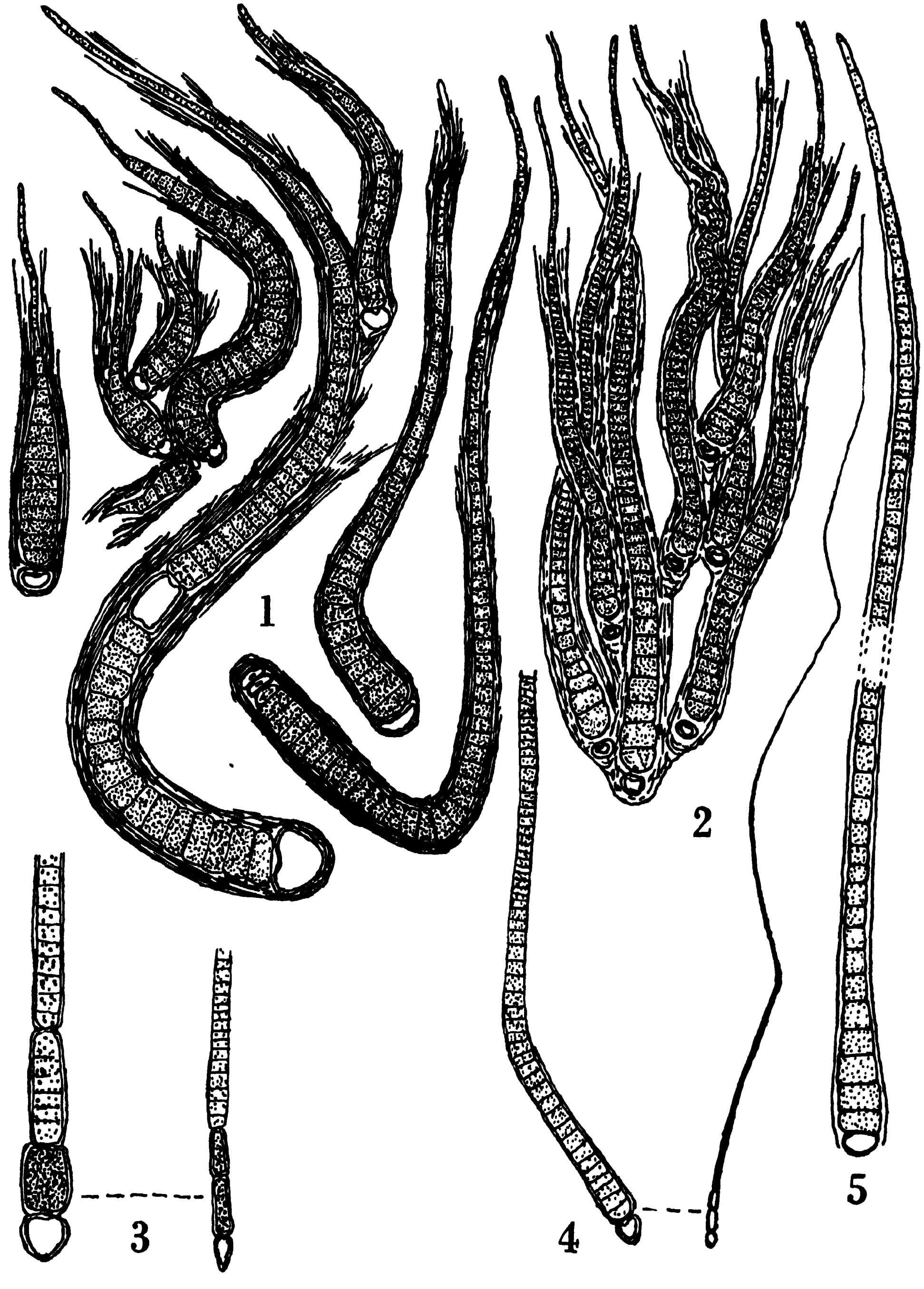

PLATE 115, Figs. 1–5.

1. *Calothrix parietina* (Näg.) Thuret (after Frémy); 2. *Rivularia dura* Roth (after Frémy); 3, 4. *Calothrix javanica* De Wilde. (after De Wildeman); 5. *C. linearis* Gardner (after Gardner).

walls, gradually tapering to a hair; cells as long as broad or shorter than broad; heterocysts single, seldom two, basal, hemispherical, 9–12 μ broad.

On moist rocks, Mysore ( ! ).

The trichomes of the Mysore specimens are (11.8–) 16.7–22.3 μ broad (Pl. 108, Figs. 1–3).

### 5. **Dichothrix orsiniana** (Kütz.) Born. et Flah.

Revision des Nostocacées hétérocystées, 376, 1886; Forti in De Toni, Sylloge Algarum, 5: 641, 1907; Frémy, Myxo. d'Afr. équat. franc., 266, fig. 239, 1929; Geitler, Kryptogamenflora, 588, 1932.

Pl. 107, Fig. 4

Thallus caespitose, fasciculate, penicillate, gelatinous, greenish brown, 2–3 mm high; filaments flexuous, 10–12 μ broad, with ultimate false branches, erect, radiating, false branches adpressed; sheath close to the trichome, thick, yellow, brownish in older parts, soft, uniform; trichome 6–7.5 μ broad, olive-green, with cells shorter than broad, gradually attenuated in a long hair; heterocysts basal, subcylindrical.

Igatpuri and Matheran, near Bombay (Schmidle, 1900b, 161; Forti in De Toni, 1907, 641).

## **RIVULARIA** (Roth) Ag.

Systema Algarum, 19, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 345, 1887.

Trichomes unbranched, more or less irregularly false branched; filaments more or less radial or parallel in a hemispherical or spherical mucilaginous colony, hollow or solid; sheath more or less gelatinizing; trichomes ending in a hair, often with distinct trichothallic growth; heterocysts basal or intercalary.; often false branching at the base; hormogonia single or in series gradually progressing towards the base from the meristematic zone; spores absent.

Type species: *R. dura* Roth.

Kirchner (1898, p. 90) enlarges the genus *Rivularia* to include spore bearing forms in the section *Gloeotrichia* (Ag.) Kirchner and Forti (1907) and Lemmermann (1910) follow the same practice. Geitler (1925, 1932, 1942), Elenkin (1949) and Fritsch (1945) keep *Rivularia* and *Gloeotrichia* distinct.

Desikachary (1946) described the germination of the heterocysts in *Rivularia manginii.*

## KEY TO THE SPECIES

1. Marine ........................................ 1. *R. bullata* (p. 549)
1. Freshwater ........................................ 2
    2. Filaments horizontal ........................ 2. *R. hansgirgi* (p. 549)
    2. Filaments more or less radial ........................................ 3
3. Thallus hard, filaments closely adpressed to each other ........................ 4
3. Thallus soft, filaments slightly adpressed, not incrusted with lime ................ 5
    4. With calcium incrustation, basal cell as long as broad .. 3. *R. dura* (p. 551)
    4. Without calcium, cells longer than broad ....... 4. *R. beccariana* (p. 551)
5. Trichomes 7–9 μ broad ................................ 5. *R. aquatica* (p. 552)
5. Trichomes narrower ........................................ 6
    6. Trichomes 3–5 μ broad, sheath lamellated .......... 6. *R. manginii* (p. 552)
    6. Trichomes 4.8–6 μ broad, sheath not lamellated ..... 7. *R. globiceps* (p. 552)

### 1. **Rivularia bullata** (Poir) Berk. ex Born. et Flah.

Berk., Glen. Brit. Alg., 8, pl. 2, fig. 1, 1833; Bornet and Flahault, Revision des Nostocacées hétérocystées, 358, 1886; Forti, in De Toni, Sylloge Algarum, 5: 660, 1907; Geitler, Kryptogamenflora, 648, 1932; Frémy, Cyano. Cotes d'Eur., 155, pl. 44, fig. 1, 1933.

Thallus expanded, vesicular, lobed, bullose-confluent, up to 6 cm. diam., blue-green; filaments not easily seen owing to being closely adpressed; sheath distinct, hyaline, seldom yellowish, diffluent or gelatinized and lost in the upper part; trichome 5–8 rarely 10 μ broad, attenuated into a hair, slightly constricted at the cross-walls; cells at the base as long as broad, and above up to ⅓ as long as broad.

On damp soil near river side, Lahore (Ghose, 1919, 12).

According to Ghose the heterocysts are globose and 6–8 μ thick.

*Rivularia bullata* has been known from marine habitat commonly and Ghose's record is therefore interesting ( ? ) in that it was growing on soil.

### 2. **Rivularia hansgirgi** Schmidle

Kneucker's Allg. bot. Zeitschr., 6: 34, 1900a; Über einige von Prof. Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 173, pl. 9, figs. 23–25, 1900b; Forti, in De Toni, Sylloge Algarum, 5: 662, 1907; Geitler, Kryptogamenflora, 649, 1932.

Pl. 112, Fig. 7

Thallus expanded, nostocoid, flat, gelatinous, thin, solid, black or blackish brown; trichome long, horizontally expanded, generally intricate and curved; rarely subparallel, at the end gradually tapering, in the middle 6 μ broad, at the apices 2–4 μ broad; distinctly torulose; sheath thin, colourless or pale yellow; rarely branched, base of branches with a heterocyst; cells rectangular or

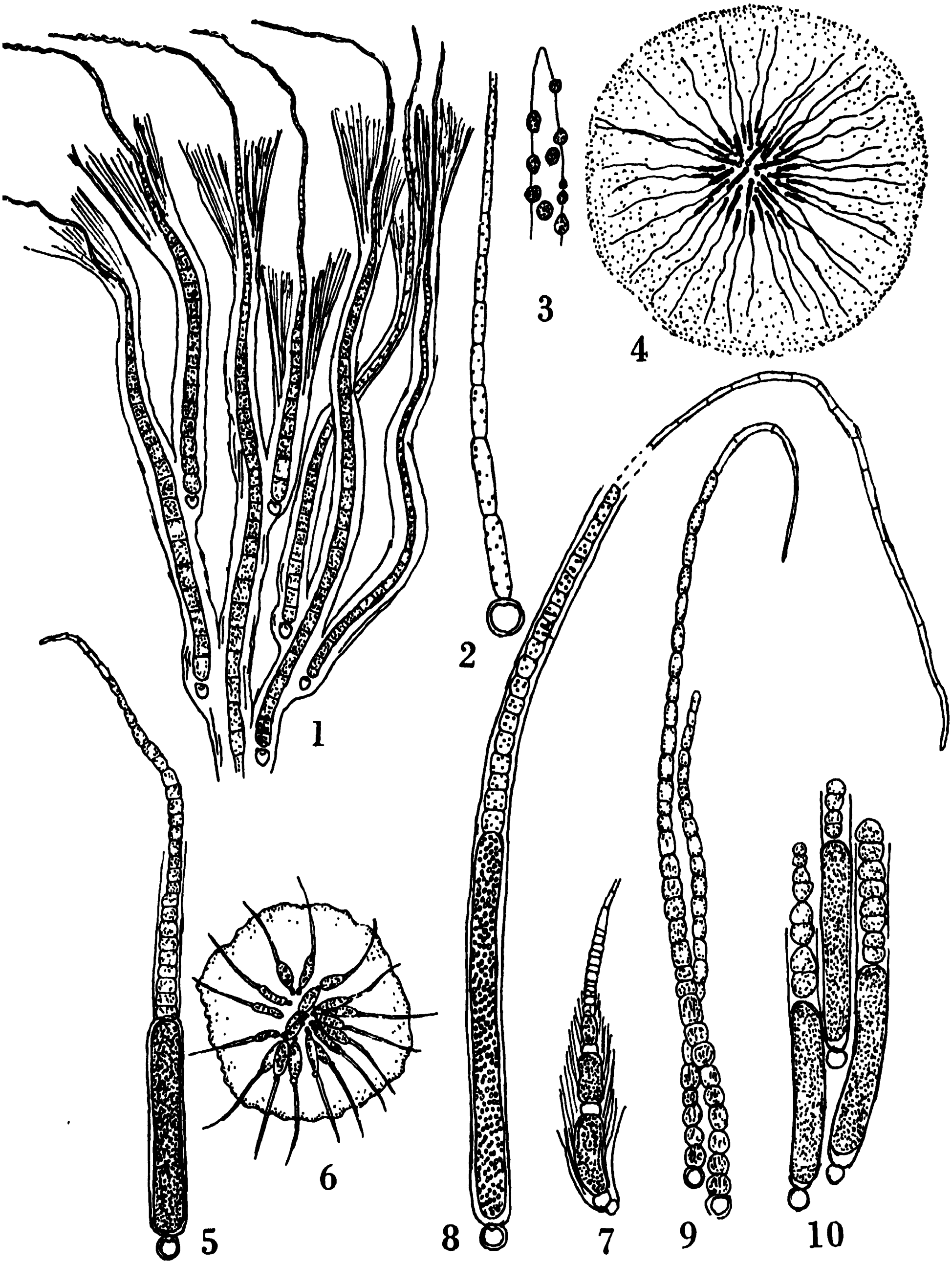

PLATE 116, Figs. 1–10.

1. *Rivularia beccariana* (after Frémy); 2, 3. *R. aquatica* De Wilde. (after West); 4, 5. *Gloeotrichia pisum* Thuret (after Frémy); 6, 7. *G. pilgeri* Schmidle (after Schmidle); 8. *G. intermedia* (Lemm.) Geitler (after Poljansky); 9, 10. *G. echinulata* (Smith, J. E.) Richter (after Richter).

subquadrate, at the base shorter than broad; heterocysts basal, single or two together, hyaline, about 8 μ diam.

Between mosses on earth, Igatpuri near Bombay (Schmidle *loc. cit.*).

The species is differentiated by the prostrate habit. The presence of hairs at both ends suggests a similarity to *Camptothrix*. Geitler (1932) suggested that it may be an extreme case of germination of hormogones.

### 3. **Rivularia dura** Roth ex Born. et Flah.

Roth, Neue Beitr. Bot., 273, 1802; Bornet and Flahault, Revision des Nostocacées hétérocystées, 347, 1886; Forti in De Toni, Sylloge Algarum, 5: 674, 1907; Frémy, Myxo. d'Afr. équat. franc., 271, fig. 242, 1929; Geitler, Kryptogamenflora, 649, fig. 412, 1932.

Pl. 115, Fig. 2

Thallus hard, calcium incrusted, blackish green up to ½ mm high; filaments densely arranged; sheath thin, hyaline, not lamellated, uniform, trichome 4–9 μ broad, blue green, when dried violet, ending in a long narrow hair, cells at the base as long as broad, above about ⅓ as long as broad.
Type not recorded.

### Var. **confluens** Frémy

Cyanophycées de l'Inde méridionale, Blumea, suppl. 2: 25, 1942.

Thallus up to 1 cm. broad, pale bluish, commonly confluent, sheath in lower parts yellowish.

On moist rocks in flowing waters in the environs of Shembaganur (Frémy, *loc. cit.*).

For a good description of the species see also Frémy, Note sur *Rivularia dura* Roth, Ann. de Protistologie, 3: 69–72, pl. 7–10, 1931.

### 4. **Rivularia beccariana** (De Not.) Born. et Flah.

Revision des Nostocacées hétérocystées, 356, 1886; Forti in De Toni, Sylloge Algarum, 5: 663, 1907; Geitler, Kryptogamenflora, 649, 1932.

Pl. 106, Figs. 8, 9 & Pl. 116, Fig. 1

Thallus hemispherical, pulvinate, sometimes confluent, olivaceous, green, hard, 1 mm thick, seldom up to 3.5 mm high; filaments 7–9 μ broad, very closely pressed together; sheath thin, indistinctly lamellated, colourless or yellow-brown; trichome 3–7 μ broad, olive-green, produced into a long very much bent hair; cells at the base longer than broad, above as long as broad.

On the rocky bed of a stream, near Tirupati ( ! ).

### 5. **Rivularia aquatica** De Wilde.

Alg. rapp. J. Massart, Ann. Buitenzorg, suppl. 1: 40, 1897; Forti in De Toni, Sylloge Algarum, 5: 663, 1907; Geitler, Kryptogamenflora, 652, 1932.

Thallus spherical up to 2 mm diam., without calcium incrustation; filaments slightly pressed together; sheath thin, colourless, unlamellated, regularly attenuated at the ends; trichome 7–9 μ broad, ending in a long thin hair; cells at the base longer than broad, near the apex longer.

On *Nitella,* in running trench water, Rangoon (Skuja, 1949, 28).

Geitler (Arch. Hydrobiol. u. Planktonk., suppl. 14: Tropische Benningewasser, 6: 439, figs. 72a-m, 1935) includes *R. aquatica* in *R. globiceps.*

### 6. **Rivularia manginii** Frémy

Deux Cyanophycées, Travaux Cryptogamiques dedies a Louis Mangin, 103, pl. 1, 1931; Cyanophycées de l'Inde Méridionale, Blumea, suppl. 2: 22, 1942.

Pl. 106, Figs. 3, 11 & Pl. 109, Fig. 17

Thallus spherical or subspherical, solitary or gregarious, not confluent, olive-green in colour, ¼–6 mm diam., soft, elastic, solid, nonzonated, no calcium incrustation; filaments radially disposed, sheath broad, at base 10–12 μ broad, broadening above, apex, 30 μ broad and funnel shaped, subhomogeneous, delicately lamellated, hyaline, sometimes golden yellow or brownish; trichome 3–5 μ broad, not constricted, attenuated, ending in a long and thin hair; cells 1–1½ as long as broad, young ones shorter; heterocysts basal, solitary, or 2–4 together.

In between other algae on aquatic plants, in stagnant waters, Shembaganur (Frémy, *loc. cit.*); on moist rocks heavily sprayed by a water fall, Tirupati (Desikachary, 1946, 14).

#### Var. **confluens** Frémy

Cyanophycées de l'Inde méridionale, Blumea, suppl. 2: 26, 1942.

Thallus confluent, more or less verrucose, or lobated.

With the type, Shembaganur (Frémy, *loc. cit.*).

### 7. **Rivularia globiceps** West, G. S.

J. Linn. Soc. Bot. Lond., 38: 182, pl. 10, fig. 6, 1907; Frémy, Myxo. d'Afr. équat. franc., 271, fig. 243, 1929; Geitler, Kryptogamenflora, 652, fig. 415, 1932.

Thallus small, soft, 1.5–3 mm broad, hemispherical to spherical without calcium incrustation; filaments highly adpressed; sheath colourless thick, unlamellated; trichome ending a long hair, 4.8–6 μ broad, constricted at the cross-walls; cells cylindrical, at the base 1½–4 times as long as broad, above as long or twice as long as broad; heterocysts spherical, 10–12 μ broad, single seldom two together.

Type not recorded.

Rao, (The Myxo. of the Madras Presidency, I, J. Indian bot. Soc., 27: 85, 1938a) describes a form.

Trichomes at the base 3.2–4 μ broad, higher up 0.8–1 μ broad; cell at the base 3.2–11.2 μ long, higher up 2.4–3.2 μ long; heterocysts 4.8–8 μ broad and 6.4–9.6 μ long.

In a stagnant puddle, in a hillock extending into the sea, Vizagapatam (Rao, *loc. cit.*).

## SPECIES INQUIRENDA

### **Rivularia peguana** Zeller

Algae collected by Mr. S. Kurz in Arracan and British Burma, J. asiatic Soc. Bengal, 42: 181, 1873a; Hedwigia, 12: 172, 1873b; Forti in De Toni, Sylloge Algarum, 5: 677, 1907,

Thallus gelatinous, indefinitely expanded, olivaceous, soft, hyaline; filaments blue-green, 7.5 μ broad at the base and 4.5 μ broad above, apex more or less acuminate, loosely intricate, flexuous; cells moniliform, subquadrate, 2 times as long as broad; cells subglobose, 7.5–12 μ diam.

On submerged dead trees in Kadeng-Choung near Natmadhi (Zeller, *loc. cit.*; Theobald, 1883, 22).

## **GLOEOTRICHIA** Ag.

Alg. Maris et Adriati., 8, 1842; Bornet and Flahault, Revision des Nostocacées hétérocystées, 365, 1886.

Thallus spherical or hemispherical, solid, sometimes when old inflated and hollow; filaments radial more or less parallel, often with false branches; sheath at the base firm, only gelatinizing on the outside, soft to mostly diffluent; trichomes with a distinct trichothallic growth; heterocysts basal; spores at the base of the trichome, single or a few next to the heterocyst; hormogones present.

Lectotype: Geitler (1942, p. 168) proposes *Gl. pisum* Thuret as the type.

Geitler (1932, p. 631) says that the heterocysts are either basal or intercalary. Bornet and Flahault (1886) mention only basal heterocyst. In some species heterocysts are again formed after a spore is formed. But it has been generally found that these are one pored and are either terminal or basal.

Hence these may not be considered as intercalary and do not have a two pored condition.

Structure and growth of the trichome, the fromation of the colonies, the mode of formation of heterocysts and their germination and the mode of formation of spores and germination has been well studied in the genus by a number of workers (Schwendener, 1894; de Bary, 1863; Bornet and Thuret, 1880; Geitler, 1936; Elenkin, 1936, 1949; Desikachary, 1946).

The presence of a distinct meristematic region has been pointed out by Schwendener. Until spore formation it is generally this region that is often the broadest. But with the onset of spore formation changes take place in the trichome immediately next to the heterocysts. Usually these cells do not divide. But prior to spore formation the lowermost cell becomes enlarged and divides. This is repeated and the lowermost cells gradually increase in size. Ultimately the lowermost cell becomes marked out as the spore forming cell. The cell enlarges to and also elongates to many times the length and becomes converted into a spore. The spores have two distinct walls, generally a thick exospore and an endospore. The connection between the heterocyst and the spore is retained till the very end until the spore is fully formed. The formation of the spore leads to the breaking away of the rest of the trichome. Very often the next cell dies and before then a wing like structure is formed at the apex, repeatedly gradually reducing the waist and then the trichome breaks away. There is generally a single spore formed. But in some two or more are formed. In the latter case the lowermost cell becomes a heterocyst and then a spore is formed next to it.

Simultaneous with the formation of the spore a distinct often pigmented sheath begins to be formed around the lower portion of the trichome where the spore forming cell is located, and looks as if it were a thick protective covering around the spore. In the purely vegetative condition the sheath is not very distinctly seen as for instance is seen in *Calothrix*, *Dichothrix* or even *Rivularia*.

Germination for the spore has been observed in a number of the species of the genus (de Bary, 1863; Bornet and Thuret, 1880; Palik, 1935; *see* also Pl. 11, figs. 13–21). By a transverse division the contents divide into a two celled germling. By further transverse divisions the germling becomes eight or more celled. At this stage the germling trichome is still enclosed within the old spore wall and consists of barrel-shaped or quadrate cells. The spore wall then gets ruptured at the apex by the slow dissolution and the terminal portion is carried off at the end of growing germling. Very often the spore wall gets dissolved only on one side near the tip and the germling trichome grows out through this and bends forward. The germling trichome grows longer at the end. It becomes narrower and its cells longer and cylindrical at the end. The contents of the cells become very much vacuolated. The projecting trichome portion, by further elongation finally becomes a long hair. As regards the cells inside the old spore wall they are short and possess dense contents and are quadrate in shape. The basal cell becomes slightly larger and rounded, its contents become finely granular and it becomes converted into a heterocyst.

Germination of the spore has been observed by De Bary (1863), Bornet and Thuret (1880) and the present author in *Gl. natans* and *Gl. punctulata* and Palik in *Gl. tuzonii.* De Bary observed that the germling after reaching a certain length escapes out of the spore wall. The germling trichome then breaks up into five to seven pieces about equal in length and in the number of cells. The pieces place themselves close together forming a bundle and get themselves transformed into rivulariaceous filaments. One terminal cell becomes a basal heterocyst and at the other end a hair is formed. In the present author's observation based on *in situ* germination the terminal portion of the germiling was observed to break off into a few celled hormogones and is very similar to that seen in *Gl. punctulata* by Bornet and Thuret.

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Thallus hard | 1. *Gl. pisum* (p. 555) |
| 1. | Thallus soft | 2 |
| 2. | Without gas vacuoles | 3 |
| 2. | With gas vacuoles | 2. *Gl. echinulata* (p. 556) |
| 3. | Thallus with only a few filaments, spores cylindrical, ending gradually in a short hair | 3. *Gl. pilgeri* (p. 558) |
| 3. | Thallus with many filaments | 4 |
| 4. | Hairs protruding out of the colony | 5 |
| 4. | Hairs not protruding out of the colony | 6 |
| 5. | Sheath lamellated | 3. *Gl. pilgeri* (p. 558) |
| 5. | Sheath unlamellated | 4. *Gl. longicauda* (p. 558) |
| 6. | Spores with smooth outer walls | 7 |
| 6. | Spores punctate or granulated | 5. *Gl. indica* (p. 560) |
| 7. | Trichome few celled below the hair | 5. *Gl. indica* (p. 560) |
| 7. | Trichome many celled below the hair | 8 |
| 8. | Sheath more or less close to the spores not saccate | 6. *Gl. intermedia* (p. 560) |
| 8. | Sheath more or less saccate at the base | 9 |
| 9. | Cells less than 9 μ broad | 10 |
| 9. | Cells broader, 9–11 μ broad | 7. *Gl. ghosei* (p. 561) |
| 10. | Spores up to 55 μ long | 11 |
| 10. | Spores 100–250 μ long | 8. *Gl. natans* (p. 561) |
| 11. | Cells 7.5–8 μ broad; spores 13 μ broad | 9. *Gl. kurziana* (p. 562) |
| 11. | Cells 7–8 μ broad; spores 15–25 μ broad | 10. *Gl. raciborskii* (p. 562) |

### 1. **Gloeotrichia pisum** Thuret ex Born. et Flah.

Thuret, Essai de Class. des Nostocacées, Ann. Sci. nat. Sci., ser. 6, 1: 382, 1875; Bornet and Flahault, Revision des Nostocacées hétérocystées, 366, 1886; Frémy, Myxo. d'Afr. équat. franc., 273, fig. 244, 1929; Geitler, Var. **berhampurense** Rao, C. B.

The Myxophyceae of the Orissa Province, Proc. Indian Acad. Sci., B, 8: 161, fig. 1C-E, 1938b.

Pl. 118, Figs. 12, 13

Thallus spherical, small, hard, 1–2 mm in diam.; filaments with a firm, thick, stratified, yellowish brown sheath; trichome 6–9 μ broad, up to 400 μ long, cells at the base barrel-shaped and 4–10 μ long, higher up quadratic or cylindrical and 4–8 μ long, at the apex long cylindrical and 9.8–12.2 μ long; heterocysts single, spherical, subspherical, 9–12.2 μ broad; spores cylindrical with a smooth hyaline outer wall, 7.8–9.5 μ broad, with sheath 11.7–15 μ broad and 67–205 μ long.

On *Chara* and other aquatic angiosperms in a pond, Berhampur, Orissa (Rao, C. B., *loc. cit.*).

3. **Gloeotrichia pilgeri** Schmidle

Bras. Alg., Hedwigia, 40: 54, pl. 4, figs. 14–15, 1901; Forti in De Toni, Sylloge Algarum, 5: 653, 1907; Geitler, Kryptogamenflora, 641, fig. 408, 1932.

Pl. 116, Figs. 6, 7 and Pl. 118, Fig. 8

Thallus hemispherical, 200–300 μ diam., filaments radiating, about 150 μ long, not branched, base with 2–3 heterocysts; sheath at first hyaline, later yellowish brown and diffluent; trichome 8 μ broad, ending in a short hair, cells torulose, isodiametric or about ½ to as long as broad, apex round; heterocysts basal, often two and intercalary, between spores; spores ellipsoidal or cylindrical with rounded ends, mostly curved, or bent, with smooth nearly dark brown outer wall, 12–16 μ broad and 29–50 (–70) μ long.

On *Isoetes* in a tank at Vandalur near Madras ( ! ).

4. **Gloeotrichia longicauda** Schmidle

Hedwigia, 40: 51, pl. 3, figs. 4–5, 1901; Geitler, Kryptogamenflora, 641, 1932.

Pl. 117, Figs. 1, 7, 8

Thallus hemispherical, ½–⅓ mm diam., mostly solid filaments radiating about 1 mm long, 24–30 μ broad; sheath somewhat diffluent, not lamellated, colourless; trichome gradually attenuated into a long hair; cells as long as broad or somewhat longer or shorter than broad, 6–8 μ broad; heterocysts mostly many, of varying diameter; immature spores rounded, cylindrical or

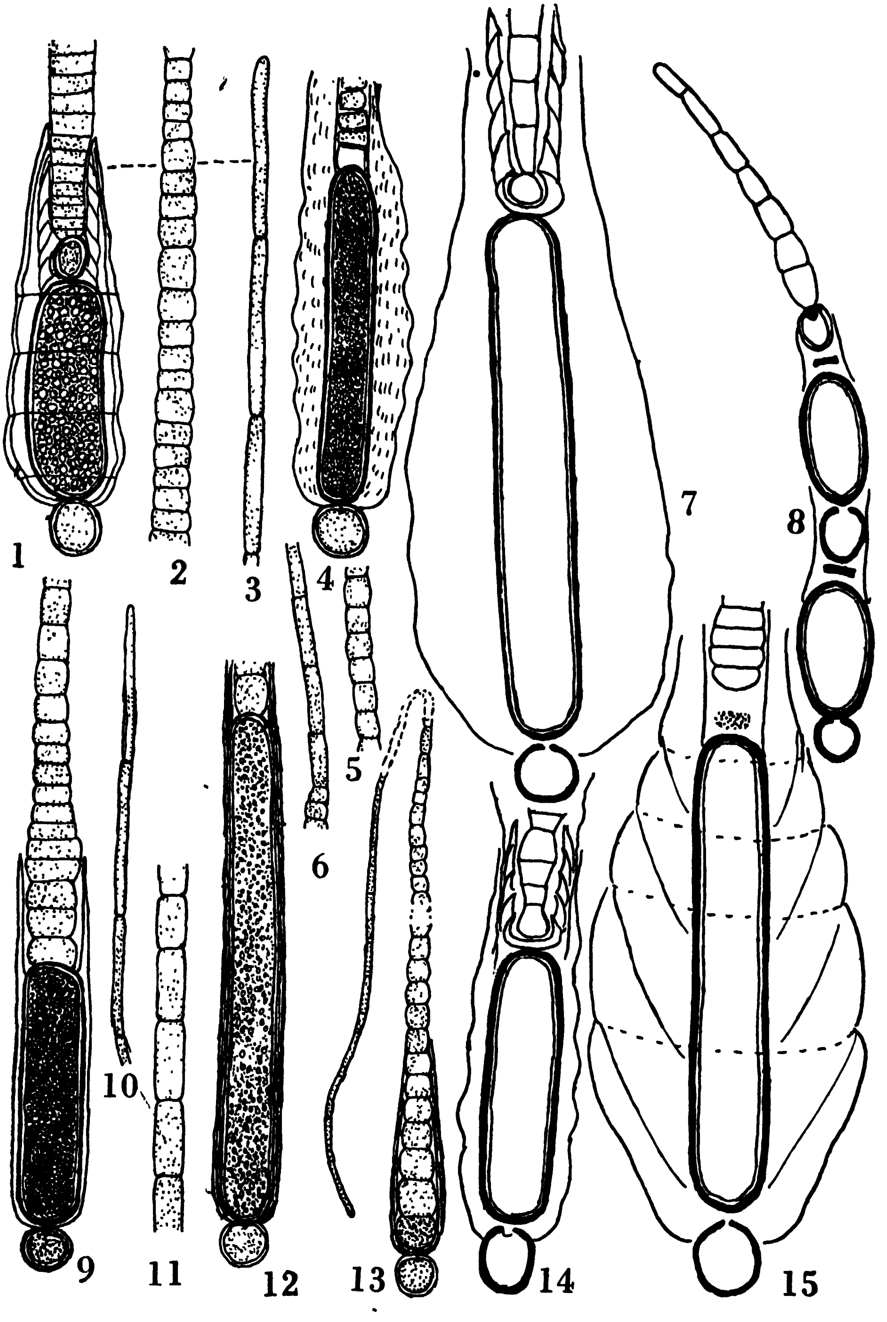

PLATE 118, Figs. 1–15.

1–3. *Gloeotrichia ghosei* Singh, R. N. (after Singh, R. N.); 4–6. *G. raciborskii* v. *longispora* Rao, C. S. (after Rao, C. S.); 7, 15. *G. natans* Rabenh. (orig.); 8. *G. pilgeri* Schmidle (orig.); 9–11. *G. intermedia* v. *kantwaensis* Rao, C. B. (after Rao, C. B.); 12, 13. *G. echinulata* v. *berhampurense* Rao, C. B. (after Rao, C. B.); 14. *G. raciborskii* Wolosz. (orig.).

long ellipsoidal, later bent or curved, about 16 μ broad and 40 μ long, epispore colourless.

Rangoon, Burma (Skuja, 1949, 28).

Skuja (*loc. cit.*) gives a detailed description of this species:—Filaments up to 25 μ broad; trichomes 6–8 μ broad below and about 5 μ broad above and 2–2.5 μ broad in the hair region; cells cylindrical or barrel-shaped and 3/5 to as long as broad, above up to twice as long and in the hair up to 20 μ long; heterocysts round, long-oval, 9–10 μ long and 6.8–9 μ broad; spores 11–14 μ broad and 22–38 μ long.

### 5. **Gloeotrichia indica** Schmidle

Allg. bot. Zeitschr., 35, 1900a; Ueber einige von Prof. Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 174, pl. 9, figs. 18–19, 1900b; Geitler, Kryptogamenflora, 639, 1932.

Pl. 112, Figs. 5, 6

Thallus spherical, soft, 1–2 mm diam., hollow (or solid), filaments radiating 200–300 μ long; trichomes made of 2–3 cells, cells barrel-shaped and about 8 μ broad, and a long narrow hair with cylindrical cells; spores nearly cylindrical, 60–70 μ long, without sheath 18–20 μ broad, with sheath 20–26 μ broad, sheath at first hyaline later yellowish brown and close to the trichome.

In a lake at Igatpuri, near Bombay (Schmidle, *loc. cit.*).

### 6. **Gloeotrichia intermedia** (Lemm.) Geitler

in Pascher's Süsswasserflora, 12: 233, 1925b; Kryptogamenflora, 635, 1932.

Pl. 116, Fig. 8

Thallus spherical, soft, 3–7 mm diam., filaments less densely packed, slightly pressed together; sheath close to the trichome, colourless; trichome ending in a hair which is many times coiled or bent 5.5–8 μ broad; cells longer than broad, seldom quadrate, blue-green; heterocysts spherical or elongate, (8–) 9.5–14 (–16) μ broad, single or two together; spores cylindrical with smooth, colourless outer wall, without sheath (7–) 11–13.5 μ broad, with sheath 14–15 μ broad, 55–135 (–154) μ long.

Epiphytic on grass blades in stagnant waters, Rangoon, Burma (Skuja, 1949, 28).

### Var. **kanwaensis** Rao, C. B.

The Myxophyceae of the United Provinces II, Proc. Indian Acad. Sci., B, 3: 168, fig. 2A-C, 1936.

Pl. 118, Figs. 9–11

Thallus spherical, soft, 1–10 mm diam., filaments with a thin, hyaline and closely adpressed sheath; trichomes with constrictions at the joints at the base, 10–13 μ broad, higher up 4–6 μ broad; cells at the base of the trichome invariably flattened and barrel-shaped, higher up almost quadratic or cylindrical, in the hair long cylindrical broad, at the base 2.5–4.5 μ long, higher up 5–16 μ long with pale blue-green contents; heterocysts spherical or subspherical, usually single, rarely in pairs, 8.6–11.5 μ long; spores cylindrical, with smooth outer walls, with sheath 14–17 μ broad, without sheath 12–15 μ broad, 55–66 μ long, sheath 0.8–1 μ thick.

In rain water pool, Benaras (Rao, C. B.); U. P. Soils (Singh, 1939, 38).

De Toni (Diag. Alg. nov. I, Myxo., Cent. 8: 751, 1939–46) changes the name of the variety from *kanwaense* to *kanwaensis*.

### 7. **Gloeotrichia ghosei** Singh, R. N.

The Myxophyceae of the United Provinces, IV — Proc. Indian Acad. Sci., B, 9: 64, fig. A-C, 1939b.

Pl. 118, Figs. 1–3

Thallus free swimming, 4–5 cm. in diameter, spherical or almost ellipsoidal brown; filaments with a thin stratified and brown sheath; sometimes constricted at intervals, up to 25 μ broad, up to 1 mm long; trichome constricted at the cross walls, ending in a long hair, at the base 9–11 μ broad, higher up 3.5–6.6 μ broad; cells at the base barrel-shaped and much shorter than broad or almost quadratic and 3–7 μ long; higher up cylindrical 5–16.5 μ long, in the hair long cylindrical; heterocysts single, spherical, 9.9–13.3 μ broad and 9.9–13.2 μ long; spores long ellipsoidal with a hyaline smooth outer wall, 13.2–16.5 μ broad, with sheath 23.3–25 μ broad, 46–2–50 μ long, sheath 4–6.6 μ thick.

Floating in stagnant water in a paddy-field, Gorakhpur (Singh, *loc. cit.*).

This differs from *Gl. pisum* in having broader cells, bigger heterocysts and narrower spores which are always ellipsoidal and narrow sheath.

Singh (*loc. cit.*) states that the alga does not have any intercalary meristem.

### 8. **Gloeotrichia natans** Rabenhorst ex Born. et Flah.

Rabenh., Kryptogamenflora, 90, 1847; Bornet and Flahault, Rev. des Nostocacées hétérocystées, 369, 1886; Frémy, Myxo. d'Afr. équat. franc., 275, fig. 246, 1929; Geitler, Kryptogamenflora, 639, figs. 406, 407, 1932.

= *Rivularia natans* (Hedwig) Welwitsch, Syn. Nost. Austr. Infer., 17, 1836.

Pl. 118, Figs. 7, 15

Thallus spherical, up to 10 cm broad, soft, bullate, hollow, blackish olive green to brown, filaments loosely arranged; trichome 7–9 μ broad, olivaceous, attenuated into a long hair; cells at the base barrel-shaped, as long as broad or somewhat shorter, higher up to 4 times as long as broad; heterocysts basal, more or less spherical, 6–12 μ broad; spores cylindrical, straight or bent, without sheath 10–18 μ broad and 40–250 μ long, with sheath up to about 40 μ broad, saccate, transversely constricted, hyaline, or brownish.

Attached to submerged plants, sometimes later free floating in lakes, pools, ponds, rice fields, and rivers.—Igatpuri near Bombay (Beck and Zahlbruchner, 1897, 82); Saharanpur Dist. (Randhawa, 1936a, 406), Benaras (Rao, C. B., 1936, 169), McPherson Lake, Allahabad (Gupta, 1956, 77), Namdur and Polampur in Andhra (Rao, C. B., 1938a, 85), Gopalnagar, in Jessore Dist. (Banerji, 1938, 96) and Hooghly near Calcutta (Biswas, 1942, 198) in Bengal; River Ravi near Lahore, Pakistan (Ghose, 1924, 345); Tanu-ugyi in Shan States in Burma (Ghose 1921, 36). Also free floating in ponds, tanks and straggling portions of rivers at Madras ( ! ), Vandalur ( ! ), Mamandur and Jog ( ! ).

Both Ghose and Banerji have reported much broader spores (18–24 μ broad and 10–20 μ broad respectively).

### 9. **Gloeotrichia kurziana** Zeller orth. mut.

= *Gloiotrichia kurziana* Zeller, Algae collected by Mr. S. Kurz in Arracan and British Burma, J. Asiatic Soc. Bengal, 42: 181, 1873a; Hedwigia, 12: 172, 1873b; Forti in De Toni, Sylloge Algarum, 5: 676, 1907.

Thallus globose, about 2.5 mm diam., obscure olivaceous; filaments blue green, short subulatis; trichome at the base, 7.5–8 μ broad, half as long as broad; sheath about 15 μ broad, colourless; spores blue green, or brownish, ovate, swollen at the base, about 13 μ broad, 2–4 times as long as broad; heterocysts spherical, about 9 μ broad.

On freshwater plants, Akyab (Zeller, 18 *loc. cit.*).

This appears to be very similar to *Gl. raciborskii*. An examination of the type material is needed to settle this point.

### 10. **Gloeotrichia raciborskii** Woloszynska

Bull. Acad. Sc. Cracovie, Sect. B, 6: 687, 12, 1912; Geitler, Kryptogamenflora, 637, fig. 405a, 1932.

Pl. 118, Fig. 14

Thallus spherical, soft, 1–5 mm diam.; trichome 7–8 μ broad, ending in a long hair, with hair up to 800 μ long; sheath at the base lamellated, dull brown; cells at the base of the trichome shorter than broad, higher up as long as broad, or longer, pale blue green; heterocysts spherical, 5–6 μ broad; spores long ellipsoidal, 15–25 μ broad, up to 50 μ long with yellowish epispore.

In a temporary rain water pools, tanks and lakes.—Borivali and Bandra near Bombay (Gonzalves and Joshi, 1943a, 37; 1946, 176); Madras and Chingleput (Desikachary, 1945, 208; 1946, 11); Vandalur ( ! ) and Tirupati (!).

### Var. **bombayense** Dixit

The Myxophyceae of the Bombay Presidency Proc. Indian Acad. Sci., B, 3: 97, fig. 1, D, E, 1936.

Pl. 117, Figs. 13, 14

Filaments up to 22.5 μ broad; trichomes 3.5–6.5 μ broad; heterocysts 10–12.5 μ broad and 8.5–10 μ long; spores with brown sheath, sheath without distinct stratification.

Free floating in a stagnant rivulet, Goregaon, near Bombay (Dixit, *loc. cit.*).

### Var. **conica** Dixit

The Myxophyceae of the Bombay Presidency, Proc. Indian Acad. Sci., B, 3: 97, fig. 1, F-H, 1936.

Pl. 117, Figs. 10–12

Filaments 30–37.5 μ broad, up to 550 μ long; trichomes 5–7.5 μ broad, heterocysts up to 10 μ broad and 7.5 μ long; spores 8.5–11.5 μ broad and up to 55 μ long, with a sheath which often covers the basal heterocyst, sheath thinning out from base to apex, giving a more or less conical shape.

Free floating or attached to *Chara zeylanica,* in a stagnant pond, Santa Cruz, Bombay (Dixit, *loc. cit.*).

Rao, C. B. (1938a, 95) records the same variety from a road side pond in Namdur. The alga has broader filaments (26–40 μ), broader trichomes (6.6–9 μ), broader heterocysts (10–13 μ), and bigger spores (10–16 μ broad and 40–70 μ long).

### Var. **kashiense** Rao, C. B.

The Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 351, fig. 3, A-E, 1937b.

Pl. 117, Figs. 2–6

Thallus large, 2–10 cm diam.; trichomes with constrictions at the joints, 8.4–10 μ broad at base, higher up 4.8–6.4 μ broad, at the apex up to 3.5 μ broad; heterocysts single, spherical or ellipsoidal, 8–12.8 (–13.2) μ broad and

8.4–15 (–16.5) μ long; spores ellipsoidal with a hyaline smooth outer wall, 11.5–16 μ broad and 42–66 (–69) μ long.

In a rainwater puddle, in Benaras, (Rao, C. B., *loc. cit.*), Puri and Cuttack (Rao, C. B., 1938b, 161).

### Var. **longispora** Rao, C. S.

The Myxophyceae of the Bihar Province, I, Proc. Indian Acad. Sci., B, 9: 146, fig. 1, J-L, 1939.

Pl. 118, Figs. 4–6

Thallus up to 2.5 cm thick; trichomes constricted at the joints, at the base 7.4–9.5 μ broad, higher up 4–6 μ broad, at the apex 2 μ broad; cells at the base barrel shaped and quadratic, as long as broad or shorter, 8–12 μ long, higher up cylindrical or barrel shaped, 4–10 μ long, in the hair 14–16 μ long; heterocysts single, spherical or ellipsoidal, 12–14 (–16) μ broad; spores cylindrical with a smooth outer wall, 10–12 μ broad, 80–122 μ long, sheath 6–9.2 μ broad.

Planktonic in a pond, Dharbanga (Rao, C. S., 1939, 146).

### Var. **salsettense** Dixit

The Myxophyceae of the Bombay Presidency-I, Proc. Indian Acad. Sci., B, 3: 197, fig. 1, B, C, 1936.

Pl. 117, Figs. 9, 15

Thallus 1 cm diam., filaments 88 μ long, trichomes 5–9 μ broad, sheath up to 2 μ thick; heterocyst 7.5–14 μ broad, 10–12.5 μ long; spores 12.5–15 μ broad and up to 67.5 μ long.

Free floating in a forest pool, Borivali near Bombay.

## KEY TO THE VARIETIES

1. Spores very long .......... *longispora* (p. 564)
1. Spores not very long .......... 2
    2. Spores broader than 15 μ, not longer than 50 μ.......... *raciborskii* (p. 562)
    2. Spores not broader than 15 μ, longer than 50 μ.......... 3
3. Trichomes 3.5–6.5 μ broad .......... *bombayense* (p. 563)
3. Trichomes broader .......... 4
    4. Sheath around and spores conical .......... *conica* (p. 563)
    4. Sheath otherwise .......... 5
5. Trichome 8.4–10 μ broad .......... *kashiense* (p. 563)
5. Trichome 5–9 μ broad.......... *salsettense* (p. 564)

## APPENDIX

*Gloeotrichia atra* (Roth) Biswas, Observations on the algal collections from the Khasia and Jaintia hills, Assam, India, Hedwigia, 74: 17, pl. 1, fig. 9, 1934.

Thallus somewhat spherical, somewhat embedded in the mucous of *Gloeocapsa montana*; filaments not very long, attenuated towards the apices, fragile, widened towards the base ending in broader cells, globose, spore and distinct hemispherical basal heterocyst; sheath close, yellowish ampliated above more or less like that of *Gloeotrichia natans*; trichomes compressed, held up in the mucus, varies in dimensions, 2–6 μ in width towards the base; heterocysts basal, contiguous to the spore, hemispherical rather compressed due to pressure, 2–4 μ in diam; lower cells adjacent to the spore shorter than broad, about 4–6 μ in thickness; upper cells as long as broad or longer than broad; resting spores globose, elliptic or oblong, 12–28 μ × 8–10 μ, walls of the spores smooth; contents granular, pale blue-green.

On dripping rocks scattered in the slimy mass of *Gloeocapsa montana* at Therria, Assam (Biswas, *loc. cit.*).

# Order STIGONEMATALES Geitler

Synopt. Darst. Cyano. Beih. bot. Cbl., 41: 252, 1925.

Heterotrichous filamentous forms showing true branching, mostly with heterocysts and usually showing clear pit connections between cells. Multiplication by hormogones and pseudohormogonia, more rarely by Akinetes.

### KEY TO THE FAMILIES

1. With subdichotomous branching or pseudodichotomous or lateral branching *Capsosiraceae* (p. 565)
1. With lateral or reverse ‘ V ’-shaped branching .................. 2
    2. Pedicellate heterocysts present .................. 3
    2. Pedicellate heterocysts absent .................. 4
3. Branching true and lateral .................. *Nostochopsidaceae* (p. 567)
3. Branching reverse ‘ V ’-shaped .................. *Mastigocladopsidaceae* (p. 575)
    4. Branching reverse ‘ V ’-shaped .................. *Mastigocladaceae* (p. 577)
    4. Branching true and lateral .................. *Stigonemataceae* (p. 581)

## Family CAPSOSIRACEAE Geitler

Synopt. Darst. Cyano. Beih. bot. Cbl., 41 (3): 255, 1925.

Thallus attached more or less hemispherical with erect, free irregularly subdichotomously or laterally branched filaments; filaments with cells in one or two series; spores, heterocysts, hormogonia, planococci, and Chroococcales stages, present or absent.

A single genus reported from the region.

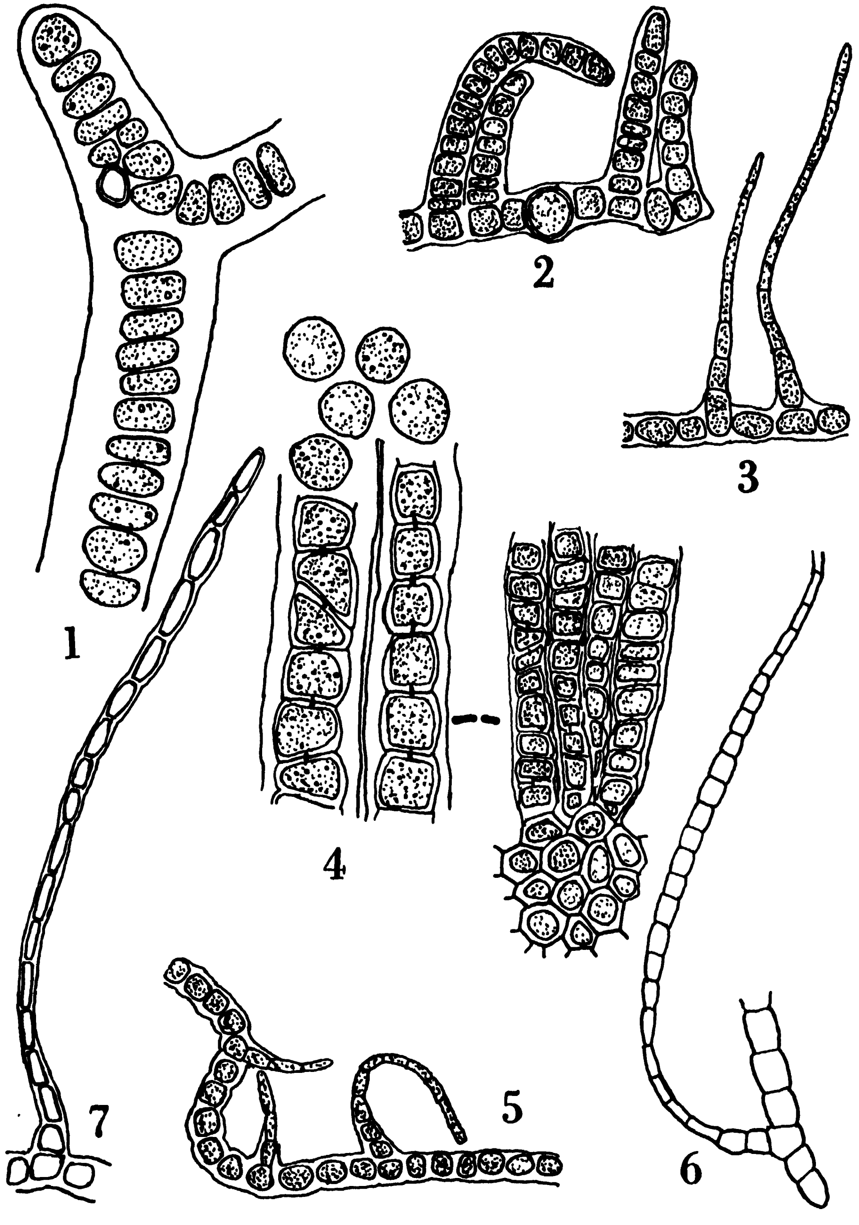

PLATE 119, Figs. 1–7.

1. *Stigonema aerugineum* Tilden (after Tilden); 2. *Hapalosiphon baronii* West et West (after West & West); 3, 5–7. *H. flagelliformis* Schmidle (after Schmidle); 4. *Stauromatonema viride* Frémy (after Govindu and Safeeulla).

### STAUROMATONEMA Frémy

Myxo. d'Afr. équat. franc., 385, 1929; em. Geitler, Arch. Hydrobiol. (u. Planktonk.), suppl. 14: 413, 1935.

Thallus slimy, firm, crustaceous, erect filaments arising from a basal horizontally creeping filaments, erect filaments densely packed, short branches which are more or less regularly dichotomously branched; sheath thin, close to the trichome, unlamellated or slightly lamellated; trichome for the major part with a single series of cells, not at all or a little torulose; cells subquadrate or rectangular heterocysts intercalary, nearly quadrate, or rectangular, in some species absent; planococci usually formed from apical cells; hormogones not known.

Lectotype: *S. viride* Frémy em. Geitler.

### Stauromatonema viride Frémy

Myxo. d'Afr. équat. franc., 390, fig. 321, 1929; Geitler, Kryptogamenflora, 468, fig. 280, 1932; em. Geitler, Arch. Hydrobiol. (u. Planktonk.), suppl. 14: 412, 1935.

Pl. 119, Fig. 4

Thallus crustaceous, gelatinous, green, expanded, attached; filaments 10–12 μ broad, branches slightly diverging from one another; sheath smooth on the outside, not homogeneous or seldom delicately lamellated; trichome 6–8.5 μ broad; cells commonly subquadrate or somewhat longer than broad; heterocysts very many as broad as the vegetative cells; planococci, discoid, 6–8 μ broad.

In a stream, at Seringapatam, Mysore State (Govindu and Safeeulla, 1950).

## Family NOSTOCHOPSIDACEAE Geitler

Synopt. Darst. Cyano., Beih. bot. Cbl., II, 41: 257, 1925.

Thallus made of erect or variously bent filaments; filaments repeatedly irregularly branched, often branched unilaterally; lateral branches generally two kinds, one long and many celled, the other with limited growth with a few cells, 1–4, mostly 1–2 celled, with a terminal heterocyst; ends of long branches with or without a long hair; hormogones present; spores not known.

### KEY TO THE GENERA

1. Thallus perforating .................................... *Mastigocoleus* (p. 573)
1. Thallus not perforating .................................... *Nostochopsis* (p. 568)

## NOSTOCHOPSIS Wood em. Geitler

Wood, Prodromus Study of the freshwater algae of eastern North America, Proc. amer. phil. Soc., 11: 126, 1869; Bornet and Flahault, Revision des Nostocacées hétérocystées, 80, 1887; em. Geitler, Diagnosen neuer Blaualgen von den Sunda Inseln, Arch. Hydrobiol. (u. Planktonk) suppl. 12: 628, 1933; Geitler and Ruttner, Die Cyanophyceen der deutschen Limnologischen, Sunda Expedition, *ibid.*, 14: 417, 1935/36.

Thallus attached at first, later free-floating with erect filaments with soft diffluent sheath, mucilaginous, more or less hemispherical, at first solid, later hollow, torn and expanded; trichome a single or two rows of branches, branches of two types, one long and many celled, the other one of limited growth with a heterocyst at the end (pedicellate heterocyst), pedicels made of one to three cells; heterocysts intercalary or terminal or pedicellate, or lateral and sessile; hormogones present; spores not known.

Type species: *N. lobatus* Wood em. Geitler.

### KEY TO THE SPECIES

1. Thallus solid when young and hollow when old ............ 1. *N. lobatus* (p. 570)
1. Thallus solid throughout ............................................ 2
    2. Intercalary heterocysts present, trichomes 1–3 μ broad 2. *N. hansgirgi* (p. 572)
    2. Intercalary heterocysts absent, trichomes in the branching zone 4–8.4 μ broad 3. *N. radians* (p. 572)

True branches occur very commonly in *Nostochopsis*. Branching generally occurs in the very young portions near the terminal portions of the radial filaments. But very frequently branching is observed in the older portions also. In the latter case a portion of the filament with very long cells divide a few times and form a row of short cells with dense contents. One of these cells bulges out slightly and a longitudinal division takes place in it cutting off an outer cell. The outer cell by further growth and repeated division gives rise to a branch. In some cases a number of more or less contiguous cells form branches. A cell after forming a branch on one side may form another branch just on the opposite side. Sometimes the cell after forming a short branch of one or two cells divides vertically (*i.e.,* the branch bearing cell) right in the middle just below the branch. Very often this branch bearing cell after bearing the branch divides obliquely in such a way that the branch stands on one of the two daughter cells of the branch bearing cell, while the other lies by the side. If the earlier stages of these division have been observed it would look as though a cell of the main filament divided obliquely and branch was formed from one of the daughter cells later on. The branch bearing cells which undergo oblique division show resemblance to similar cases in some species of *Hapalosiphon.*

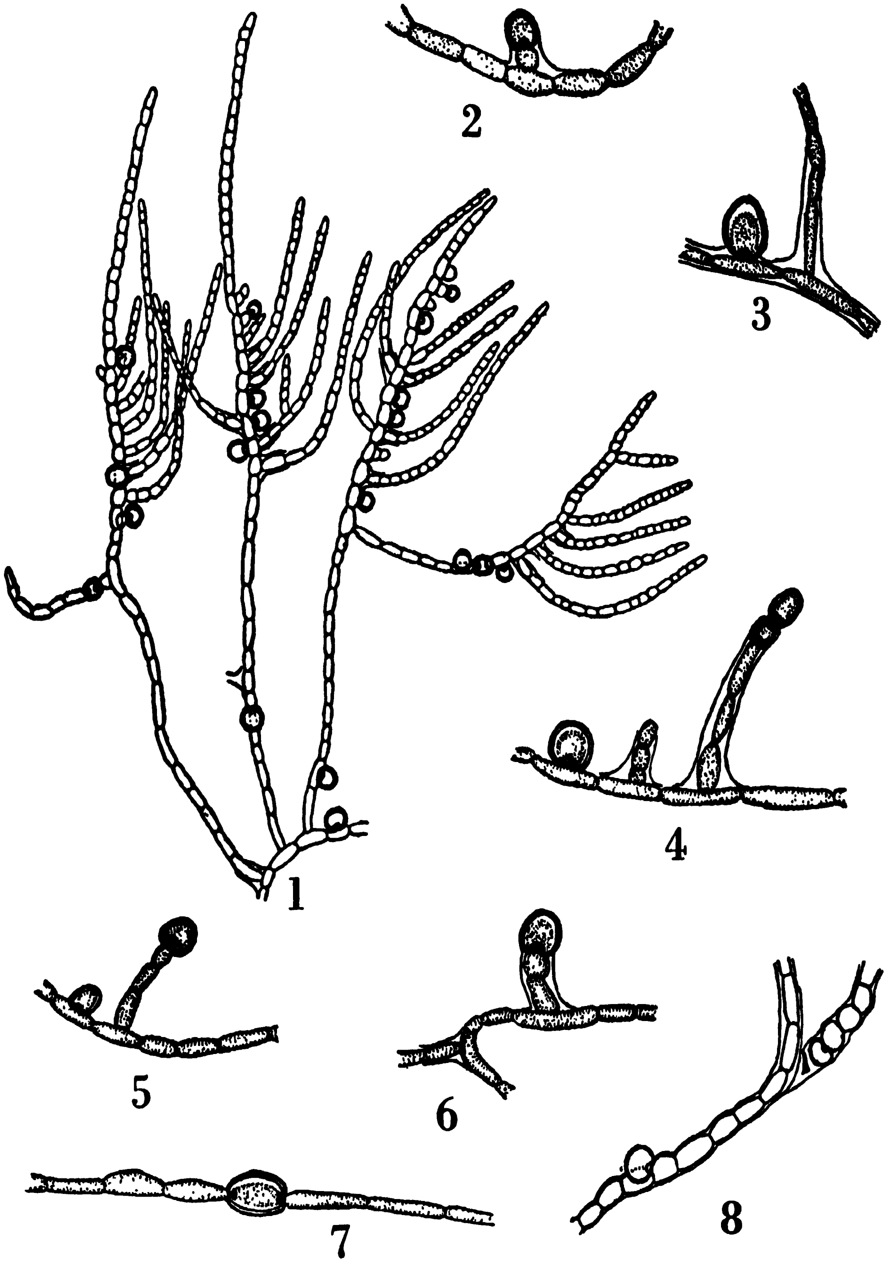

PLATE 120, Figs. 1–8.
*Nostochopsis lobatus* Wood em. Geitler (after Desikachary).

Sometimes after the formation of a branch, the cell of the main filament which forms the branch elongates gradually. The cell becomes very much elongated the branch being situated in the middle. At the point where it is connected with the branch, the lateral wall is slightly raised in a conical manner. Sometimes the younger cell in the main filament after forming a lateral branch may become divided by a transverse division unequally into a longer and shorter cell. The longer cell bears the branch and when these two cells grow longer the branch appears to be formed from one end of the cell rather than the middle of the parent cell. The longer cell bears the branch and when these two cells grow longer the branch appears to be formed from one end of the cell. Such cases are really due to division of the branch bearing cell after the formation of the branch. Similar cases of the division of the branch bearing cell dividing after the formation of the branch is also seen in *Hapalosiphon.*

In some cases the branch bearing cell elongates considerably. The cell begins to arch outwards by bending on the side opposite to the branch and has the appearance of a reverse ' V '-shaped branching with a single branch at the apex of the ' V '. Occurrence of the reverse ' V '-shaped branching in *Nostochopsis lobatus* has been earlier recorded by Frémy and Feldmann (1934) in their material from Banyuls in southern France.

### 1. **Nostochopsis lobatus** Wood em. Geitler

Wood, Prodromus Study of the freshwater algae of eastern North America, Proc. amer. phil. Soc., 11 : 119, 1869; Bornet and Flahault, Revision des Nostocacées hétérocystées, 80, 1887; Forti in De Toni, Sylloge Algarum, 5 : 592, 1907; em. Geitler, Diagnosen neuer Blaualgen von den Sunda Inseln, Arch. Hydrobiol. (u. Planktonk.), suppl. 12: Tropische Benningeswasser, 4: 628, 1933; Geitler, and Ruttner, Die Limnologischen Deutschen Sunda Inseln Expedn., *Ibid.*, 14: 417, 1935–36; Desikachary, on the genus *Nostochopsis* Wood, J. Indian bot. Soc., M. O. P. Iyengar Comm. Vol., 225, 1946.

Pl. 120, Figs. 1 8

Thallus spherical or sub-spherical, more or less irregularly lobed, solid or hollow up to 3.5 cm diam., seldom very big, blue-green or olive-green or yellowish green; trichomes radially arranged seemingly straight, in the innermost parts bent irregularly or in a zig-zag manner, lower part of the upper region richly branched, in the older parts branches scattered; branches lateral, broadly stretching upwards by a short bend and with its end being parallel to the main filament; cells in the branching zone barrel-shaped, 4–5.5 μ broad and just before formation up to 9 μ broad, mostly up to 8 μ and in older regions up to 18 μ long, trichome end tapering or slightly pointed; heterocysts mostly lateral (seesile) or terminal (pedicellate) on 2–3 or 4 celled lateral branch, more or less spherical or ellipsoidal, mostly 6–9 μ broad, seldom intercalary or basal (when young), mucilage homogeneous, colourless

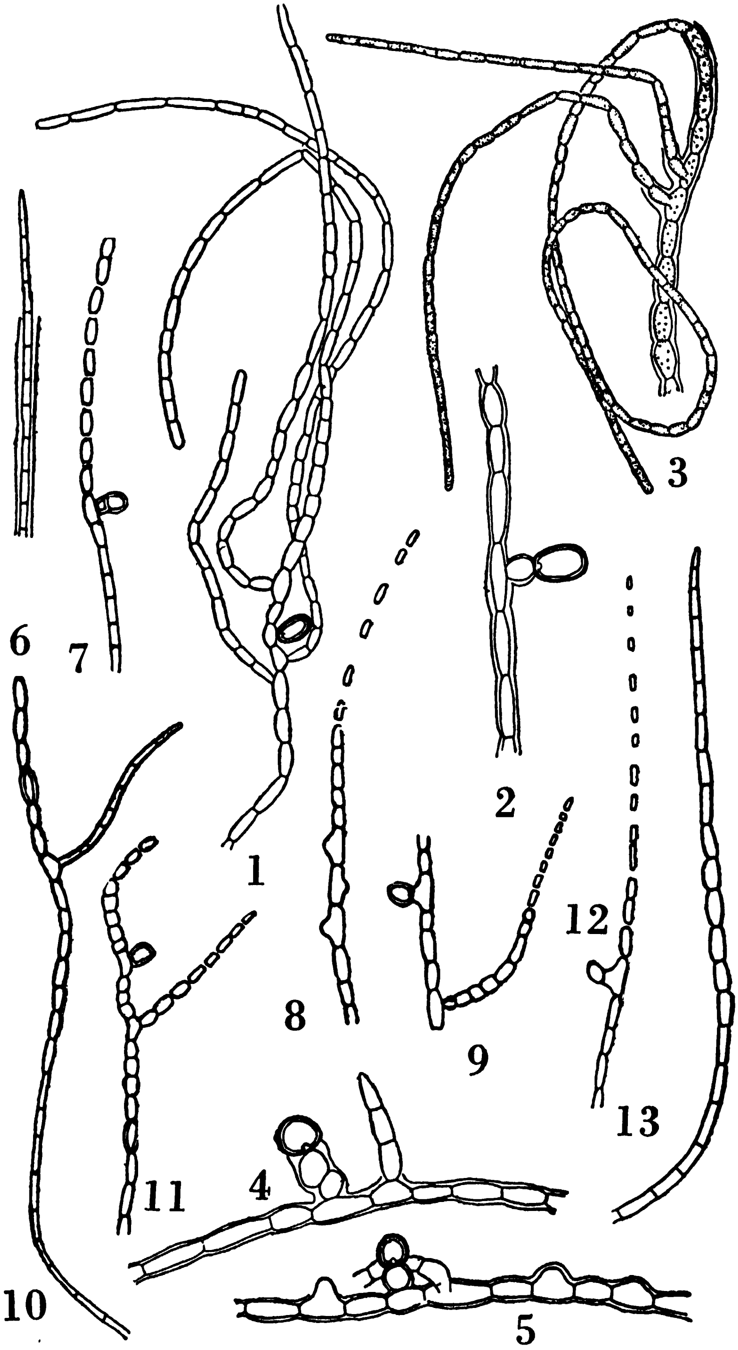

PLATE 121, Figs. 1–13.

1–5. *Nostochopsis radians* Bharadwaja (after Desikachary); 6–13. *Nostochopsis hansgirgi* Schmidle (after Schmidle).

or yellowish or brownish, sheath present in the branching zone, thin and firm, seemingly colourless or coloured yellowish to brownish, diffluent at the apices of branches, but persistent at the base; hormogones on special branches, 3–3.5 μ broad, and 8–20 cells length, cells short barrel-shaped.

In standing or in flowing waters, attached or free floating.—Paddy-fields between Kosgoda and Urahaighasmahendai and a pond near Perediniya in Ceylon (West and West, 1902, 201); Shembaganur (Frémy and Feldmann, 1934, 617); Benaras (Singh, R. N., 1939b, 64); in a stream at Anamalais near Coimbatore (Desikachary, 1946, 225); on rocks in a river at Seringapatam, Mysore State (Govindu, Razi and Safeeulla, 1949, 259); Tanuggyi canal and Royal lakes, Rangoon, in Burma (Skuja, 1949, 24).

Geitler and Ruttner and Desikachary have described very fully hormogone formation and germination in this species. Desikachary (1946, p. 235) has wrongly stated the diameter of the thallus to be up to 3.5 μ instead of 3.5 cm.

### 2. **Nostochopsis hansgirgi** Schmidle

Ueber einige von Prof. Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 178, 1900b; Forti in De Toni, Sylloge Algarum, 5: 593, 1907; Geitler, Kryptogamenflora, 477, fig. 289, 1932.

= *Nostochopsis rupestris* Schmidle, Einige neue von Prof. Dr. Hansgirg in Vorderindien gesammelte Süsswasseralgen, Allg. bot. Zeitschr., 6: 77, 1900a.

Pl. 121, Figs. 6–13

Thallus firm, spherical or irregular, yellowish brown; filaments sparsely branched, 1–2 μ broad, at the apex 0.6-0.9 μ broad, tapering to a rounded apex; cells cylindrical, occasionally constricted at the joints, light blue green, yellowish brown or greyish blue; intercalary heterocysts long ellipsoidal, or somewhat pointed at both ends, 4–5 μ broad and 6–10 μ long, lateral heterocysts spherical or hemispherical, 5 μ broad.

On moist rocks between Neral and Bombay (Schmidle, *loc. cit.*) and on rocks in a rivulet near Goregaon, Bombay (Dixit, 1936, 96).

### 3. **Nostochopsis radians** Bharadwaja

A new species of *Nostochopsis* (*N. radians* sp. nov.) New Phytol., 33: 1–7, 1934; Desikachary, On the genus *Nostochopsis* Wood, J. Indian bot. Soc., M. O. P. Iyengar Comm. Vol., 229, figs. 24–28, 1946.

Pl. 121, Figs. 1-5

Thallus hemispherical or spherical, mucilaginous, blue-green, consisting of (1) a small compact base attached to the substratum and composed of densely arranged, irregularly curved, and profusely branched filaments, (2) a middle region with loosely arranged straight or slightly curved somewhat narrower and less branched filaments running radially, and (3) an outer region of unbranched thread like and uniformly broad filaments; filaments in the older portions with a thin hyaline and firm sheath; branching true, irregularly arranged in the basal region, and generally unilateral in the middle region; when young perpendicular to the main filament, later bend and occupy a radial position; trichome blue green, cells in the basal region, more or less rounded, sometimes barrel shaped, deeply constricted at the cross-walls, up to 8.4 μ broad, in the middle region elongated and more or less barrel shaped in the inner parts and cylindrical with or without constrictions towards the outer regions, and up to 6.3 μ broad, cells in the projecting threads elongate cylindrical and 1.5 (–2.1) –2.5 μ broad and 7–50 μ long; heterocysts only lateral, sessile or pedicellate on 1–2–3-celled stalks, occurring in the basal and middle region only, spherical, ovate or obovate, 4–9 μ broad and 6–15 μ long, intercalary heterocysts absent.

Growing profusely on the rocky bed of a stream near Malnad in the Jog falls region, Mysore (Bharadwaja, 1934; Desikachary, 1946, 229) and on rocks in a small stream, Tenmalai (Desikachary, 1946, 229).

Frémy and Feldmann (1934) suggested that *N. radians* should be included in *N. lobatus*. Desikachary (1946) examining the original material and further material of the species from Tenmalai, confirmed Bharadwaja's observations and has kept the species distinct from *N. lobatus*.

## MASTIGOCOLEUS Lagerheim

Note sur la *Mastigocoleus* genre des Algues de l'ordre des Phycochromacées, Notarisia, 1: 65, 1886; Bornet and Flahault, Revision des Nostocacées hétérocystées, 54, 1887.

Thallus free, variously bent, in snail and mussel shells, creeping; trichomes made of one series of cells, seldom of two rows, irregularly branched, branching true, branches of two types, long branches ending in a long hair, the other short and cylindrical with a few cells, 1–3 cells, terminated by a heterocyst; heterocysts intercalary or lateral, or terminal, mostly single, seldom two together; sheath homogeneous, thin; hormogones present, formed by the elongate hair forming branches; spores not known.

Monotypic: *Mastigocoleus testarum* Lagerh.

Setchell and Gardner (1919, 110) and Iyengar and Desikhachary (1944, 42) have reported the formation of hormogones in *M. testarum*. A few cells below the hair portion become meristematic and begin to divide. These cells become slightly richer in contents and definitely broader than the remaining cells of the trichome above and below it. Soon the terminal hair portion is thrown off, and the meristematic cells which occupy the distal end of the

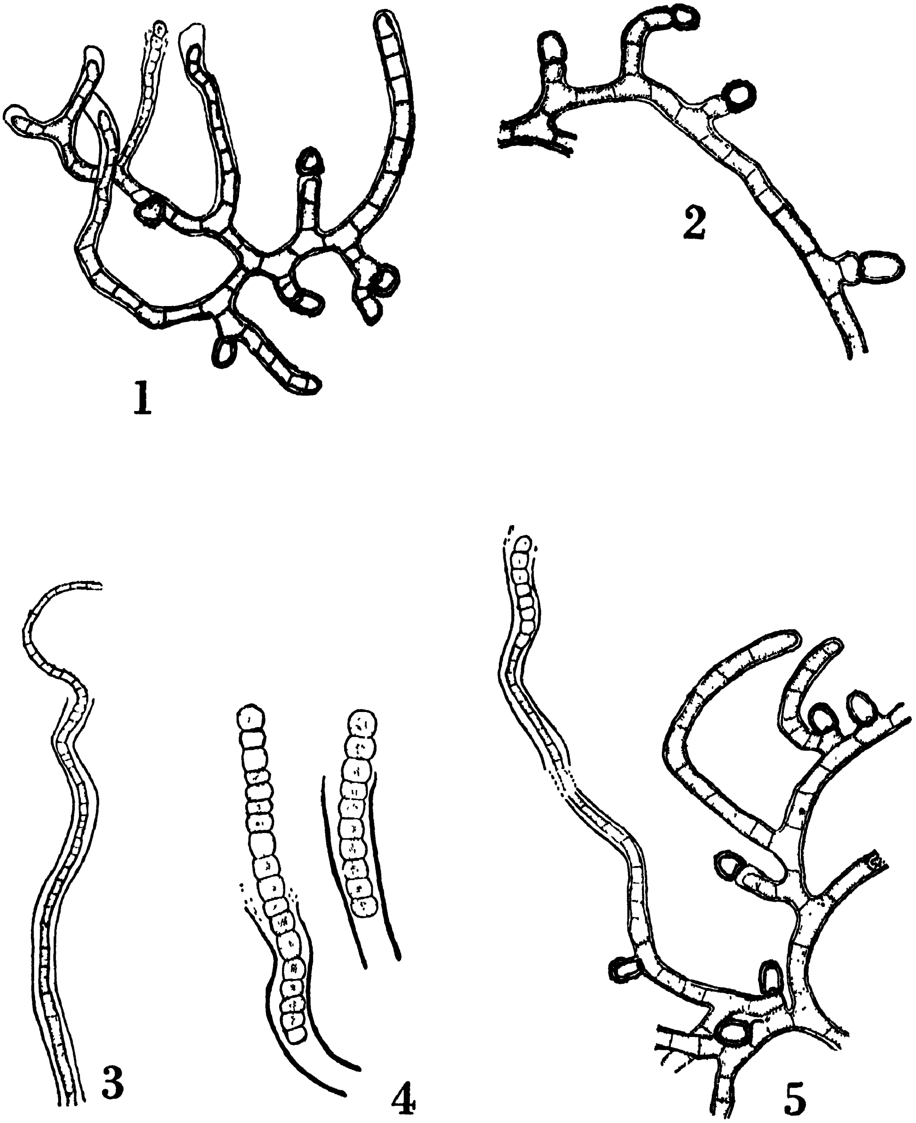

PLATE 122, Figs. 1–5.
*Mastigocoleus testarum* Lagerh. (after Iyengar and Desikachary).

trichome continue to divide and finally form a row of about 10–20 short barrel shaped cells with rich contents. This terminal portion becomes separated from the lower portion through the formation of a disc of intercellular substance or by the death of one or more cells and forms a hormogone which ultimately escapes out of the sheath at the apex of the filament. The hormogones are 2.6–3.9 μ broad.

### **Mastigocoleus testarum** Lagerh.

*loc. cit.*, 65, pl. 1, 1886; Bornet and Flahault, Revision des Nostocacées hétérocystées, 54, 1887; Forti in De Toni, Sylloge Algarum, 5: 564, 1907; Frémy, Myxo. d'Afr. équat. franc., 465, fig. 362, 1929; Geitler, Kryptogamenflora, 473, fig. 284, 1932; Frémy, Cyano. cotes d'Eur., 191, pl. 2, fig. 4, 1933.

Pl. 122, Figs. 1–5

Thallus at first thin, membranous, blue-green or rose, later perforating; filaments variously curved, 6–10 μ broad; sheath thin, hyaline; trichome 3.5–6 μ broad; cells cylindrical or subcylindrical; heterocysts broader than the trichome, 6–18 μ diam, heterocysts terminal or lateral, rarely intercalary, 6.6–7.9 μ broad and 6.6–10.5 μ long.

On shells, Krusadai island (Iyengar and Desikachary, 1944, 42); on barnacles growing on the coast of Mahabalipuram (Srinivasan, 1946, 272).

## Family MASTIGOCLADOPSIDACEAE Iyengar et Desikachary

Proc. Indian Acad. Sci. B, 24: 158, 1946.

Filaments sheathed and branched; branching both reverse 'V'-shaped and lateral; heterocysts intercalary, lateral and terminal.

### **MASTIGOCLADOPSIS** Iyengar et Desikachary

*Mastigocladopsis jogensis* gen. et sp. nov., Proc. Indian Acad. Sci. B, 24: 158, 1946.

Filaments sheathed and branched; branching both reverse 'V'-shaped and simple lateral; trichomes with a single row of cells; heterocysts intercalary, lateral or terminal; hormogones and spores not known.

Type species: *M. jogensis* Iyengar and Desikachary.

### **Mastigocladopsis jogensis** Iyengar et Desikachary

*loc. cit.*, 158, figs. 1–13, pl. 1, figs. 1–3, 1946.

Pl. 123, Figs. 1–13

Filaments flexuous, branches profuse; branching both reverse 'V'-shaped and single; branches generally thinner than the main filaments; sheaths thin,

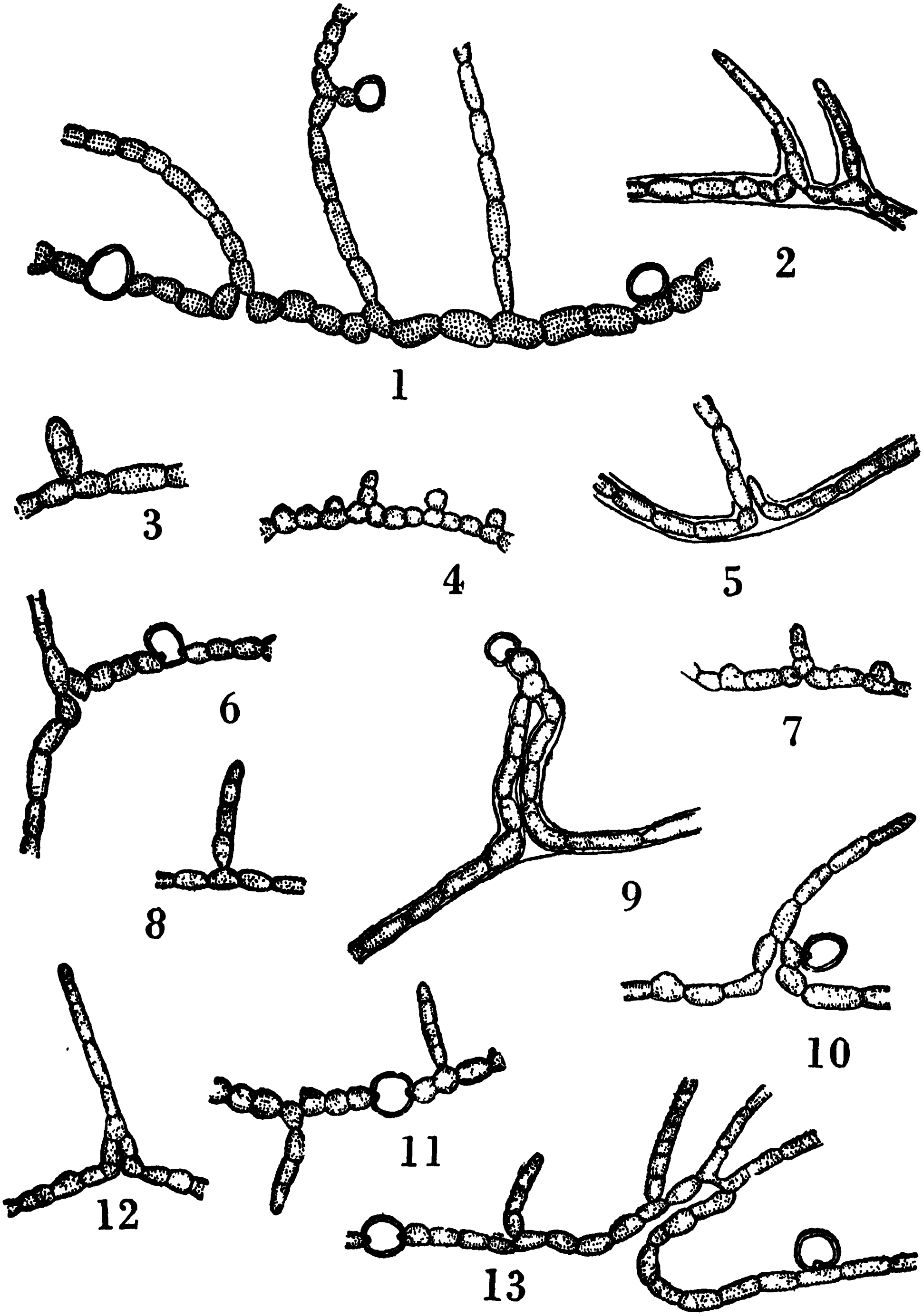

PLATE 123, Figs. 1–13.
*Mastigocladopsis jogensis* Iyengar et Desikachary (after Iyengar and Desikachary).

hyaline and unlamellated; trichome womewhat torulose in the main filaments (2.6–) 3.9–5.2 μ broad and 3.9–6.6 μ long, cells in the branches cylindrical, 2–3.9 μ broad and 6.6–14.4 μ long; heterocysts intercalary lateral and pedicellate or terminal at the end of very short branches which are 1–3 cells long; intercalary heterocystes cylindrical or ellipsoidal, 3.9–6.6 μ broad and 5.2–10.5 μ long, lateral and terminal heterocysts spherical or ovate, and 3.9–7.2 μ broad.

Growing on submerged stones in a running stream near Jog falls, Mysore state, (Iyengar and Desikachary, *loc. cit.*).

This alga has a very close resemblance to *Nostochopsis* in its general appearance and in the presence of lateral and pedicellate heterocysts. It forms profuse true lateral branching exactly as in *Nostochopsis* and *Hapalosiphon*. Seurat and Frémy have earlier described a similar form from Tunisia as *Hapalosiphon laminosus* which also belongs to this genus as has been suggested by Iyengar and Desikachary as *M. frémyii* nom. nov. (= *Hapalosiphon laminosus sensu* Seurat and Frémy [*non* Hansg.], Une Station tunisienne de l'*Hapalosiphon laminosus* Hansg., Bull. Soc. Hist. Nat. Afr. Nord, 27: 101–104, 1936.)

## Family MASTIGOCLADACEAE Geitler

Synopt. Darst. Cyano., Beih. bot. Cbl., 41(3): 263, 1925.

Trichomes with reverse 'V' shaped branching; true branches present sometimes; sheath present, firm or diffluent; heterocysts intercalary; hormogones present; spores present; endospores present in some.

### KEY TO THE GENERA

1. *Nostoc*-like thallus, trichomes radially arranged ending in a hair, marine *Brachytrichia* (p. 577)
2. Thallus not Nostocoid, filaments not ending in a hair, freshwater *Mastigocladus* (p. 580)

### BRACHYTRICHIA Zanardini

Phycearum indicarum pugillus, 24, 1872; Bornet and Flahault, Revision des Nostocacées hétérocystées, 371, 1886.

= *Hormactis* Thuret, Essai class. Nostoch., Ann. Sci. nat. bot., ser. 6, 1: 382, 1878.

incl. *Kyrtuthrix* Ercegovic, Arch. Protistenk., 66(1): 170, 1929.

Thallus more or less hemispherical or flat, gelatinous, at first solid, later hollow, *Nostoc*-like habit, part of the thallus horizontal with intricate trichomes,

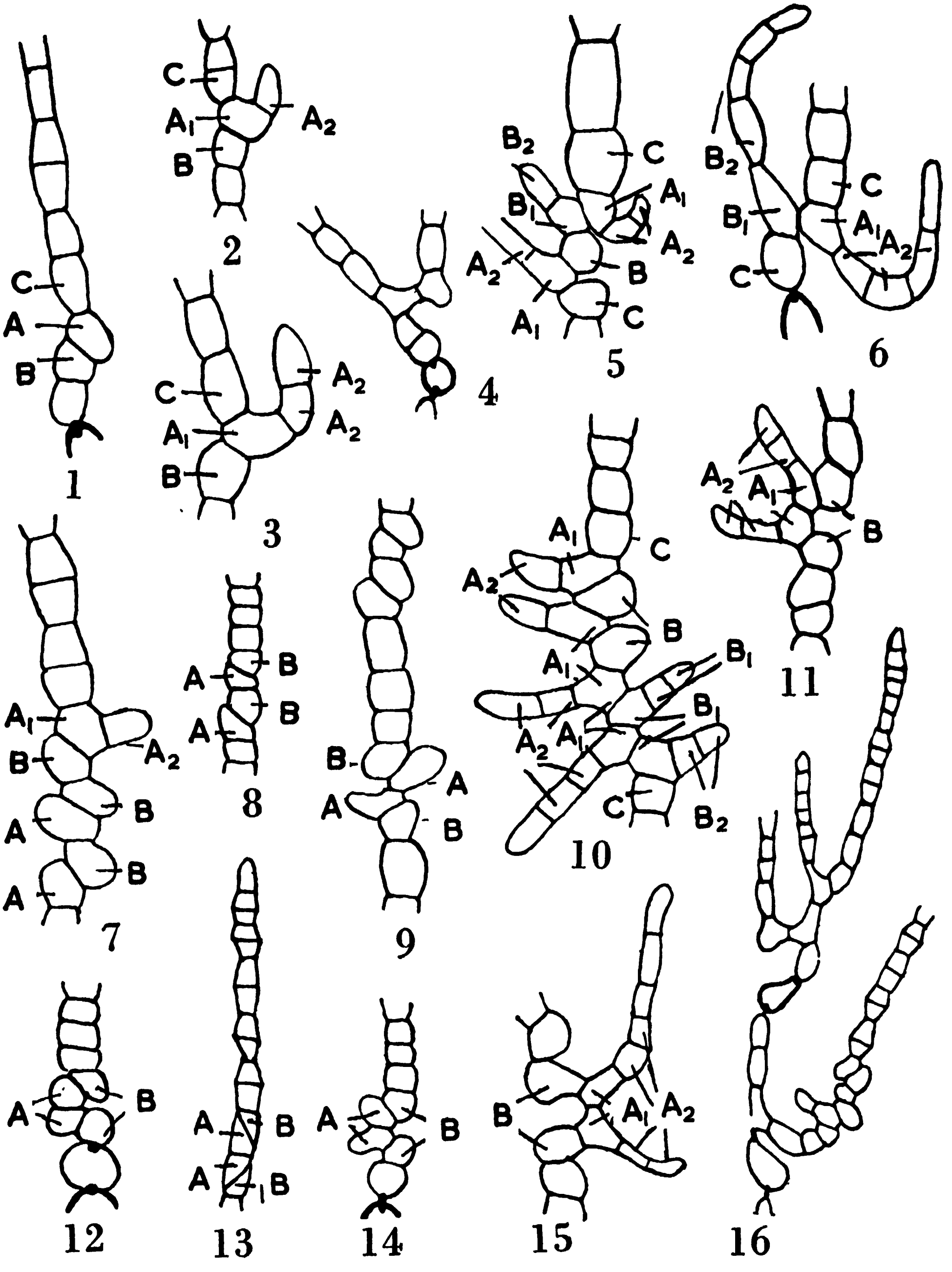

PLATE 124, Figs. 1–16.

*Brachytrichia quoyi* (Lloyd) Born. et Flah. mode of development of reverse ' V '-shaped branching (orig. after Iyengar and Desikachary).

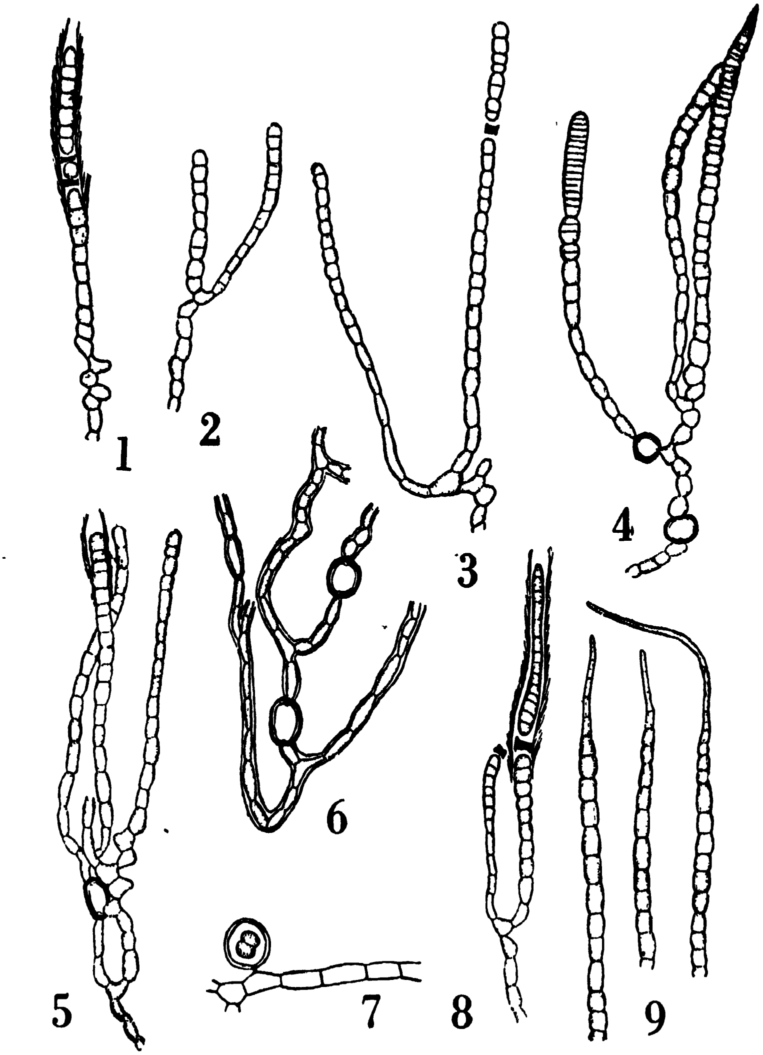

PLATE 125, Figs. 1–9.
*Brachytrichia quoyi* (Lloyd) Born. et Flah. (after Iyengar and Desikachary).

from which arise radiating-more or less parallel-filaments; branches reverse 'V'-shaped, occasionally with false branches and true lateral branches present, radial branches ending in a hair; trichome in a homogeneous but occasionally indistinct and lamellated, hard mucilage; heterocysts intercalary; hormogones present, formed from the apices of radial branches.

Type species: *Brachytrichia quoyi* (Ag.) Born. and Flah. ( = *Hormactis rivularioides* Zanard.).

Frémy (1933) retains this genus in the Rivulariaceae (cf. Bornet and Flahault, 1886, p. 371). But the correct position seems to be the Mastigocladaceae.

Frémy (1933) includes *Kyrtuthrix* under *Brachytrichia.*

### **Brachytrichia quoyi** (Ag.) Born. et Flah.

Revision des Nostocacées hétérocystées, 373, 1886.

= *Brachytrichia balani* (Lloyd) Born. and Flah., Revision des Nostocacées hétérocystées, 372, 1886; Geitler, Kryptogamenflora, 554, figs. 347 and 348, 1932; Frémy, Cyano. cotes d'Eur., 160, pl. 49, 50, and 51, fig. 1, 1933.

Pl. 125, Figs. 1–9 and Pl. 124, Figs. 1–16

Thallus a few mm to 6 cm diam., flat crustaceous or *Nostoc*-like, plicate, expanded, bullate, sometimes hollow, mostly colored dull green, when old often brown; filaments in lower portions, entangled giving rise to radial or more or less parallel arranged branches, ending in short or long hairs; sheath colorless or yellowish; cells in basal portions of the trichome 4–5 μ broad and up to twice as long as broad, cells in radial filaments short barrel shaped, 6–9 μ broad, hairs about 1 μ broad, heterocysts broader than the trichome; hormogones in series of 3–4, 20–25 μ long.

Indian Ocean, Ceylon (Ferguson colln., ex Born. and Flah., 1886, 373); on rocks below bridge, Pamban (Iyengar and Desikachary, 1944, 44), Cape Comorin (Venkataraman, 1957, 473).

Iyengar and Desikachary (1944, 46) describe hormogone formation in this species. Hormogones are abstricted from the apices of piliferous erect branches and are 6–20 cells long.

Iyengar and Desikachary (1953), have also described the occurrence of three-pored heterocysts in this alga.

Geitler (1942, p. 130) thinks that apparently there seems to be only one species.

## **MASTIGOCLADUS** Cohn

Über die Algen des Karlsbader Sprudels, Abh. Schles. Ges. Vaterl. Cultur, 2: 391, 1863.

Filaments with a single series of cells with reverse 'V' shaped short branches arising on one side, true lateral branching as well as false branches often present; sheath thin and firm or diffluent; heterocysts intercalary; hormogones not known.

Type species: *Mastigocladus laminosus* Cohn.

### **Mastigocladus laminosus** Cohn

Über die Algen des Karlsbader Sprudels, *ibid.*, 2: 39, 1863; Rabenhorst, Fl. Eur. Alg., 2: 26, 84, 1865; Frémy, Myxo. d'Afr. équat. franc., 456, 1929; Geitler, Kryptogamenflora, 558, figs. 350–352, 1932.

= *Hapalosiphon laminosus* Hansgirg, Ueber den Polymorphismus der Algen, Bot. Centralbl., 22: 48, 1885.

= *Anabaena bullosa* Kütz., Phyc. gene., 212, 1843.

Pl. 127, Figs. 1–9

Thallus membranous, carnous, spongy, firm often with calcium carbonate, nearly hard layered, blackish, blue or olive green; filaments densely entangle, 4–6 (–8) μ broad, curved, with distinct sheath, when older torulose; indistinct diffluent, side branches about 3 μ broad, erect; cells in the main filament barrel-shaped to short cylindrical, those of side branches long cylindrical; heterocysts intercalary spherical or ellipsoidal, broader than vegetative cells, up to 6.5 μ broad, single or two together.

In mud at Bala-choung, Po-swondowng, Toung-nigoo, Taittoung Valley, Burma (Zeller, 1873a, 180; Theobald, 1883, 23 as, *Anabaena bullosa.*).

Venkataraman (1957) reports the presence of three pored heterocysts in a *Mastigocladus laminosus*. He however does not give the locality of the alga.

### Var. **indicus** var. nov.

Pl. 126, Figs. 1–4

Filaments interwoven, 6.6–9.2 μ broad, with branches given off on either side, sheath fairly thick, hyaline and unlamellated in older filaments slightly diffluent; trichomes not forming hairs, torulose or slightly constricted; cells barrel shaped in the main filament, and long cylindrical in the branches, (2.7–) 3.9–6.6 μ broad and (5.2–) 9.2–14.4 μ long; heterocysts intercalary, quadratic or ellipsoidal, 3.9–6.5 μ broad and 7.9–13.1 (–22.3) μ long, single or rarely two together.

On dripping rocks, Kodaikanal ( ! ).

## Family STIGONEMATACEAE Kirchner

Schizophyceae in Engler and Prantl, Die natürlichen Pflanzenfam., I, la, p. 80, 1898.

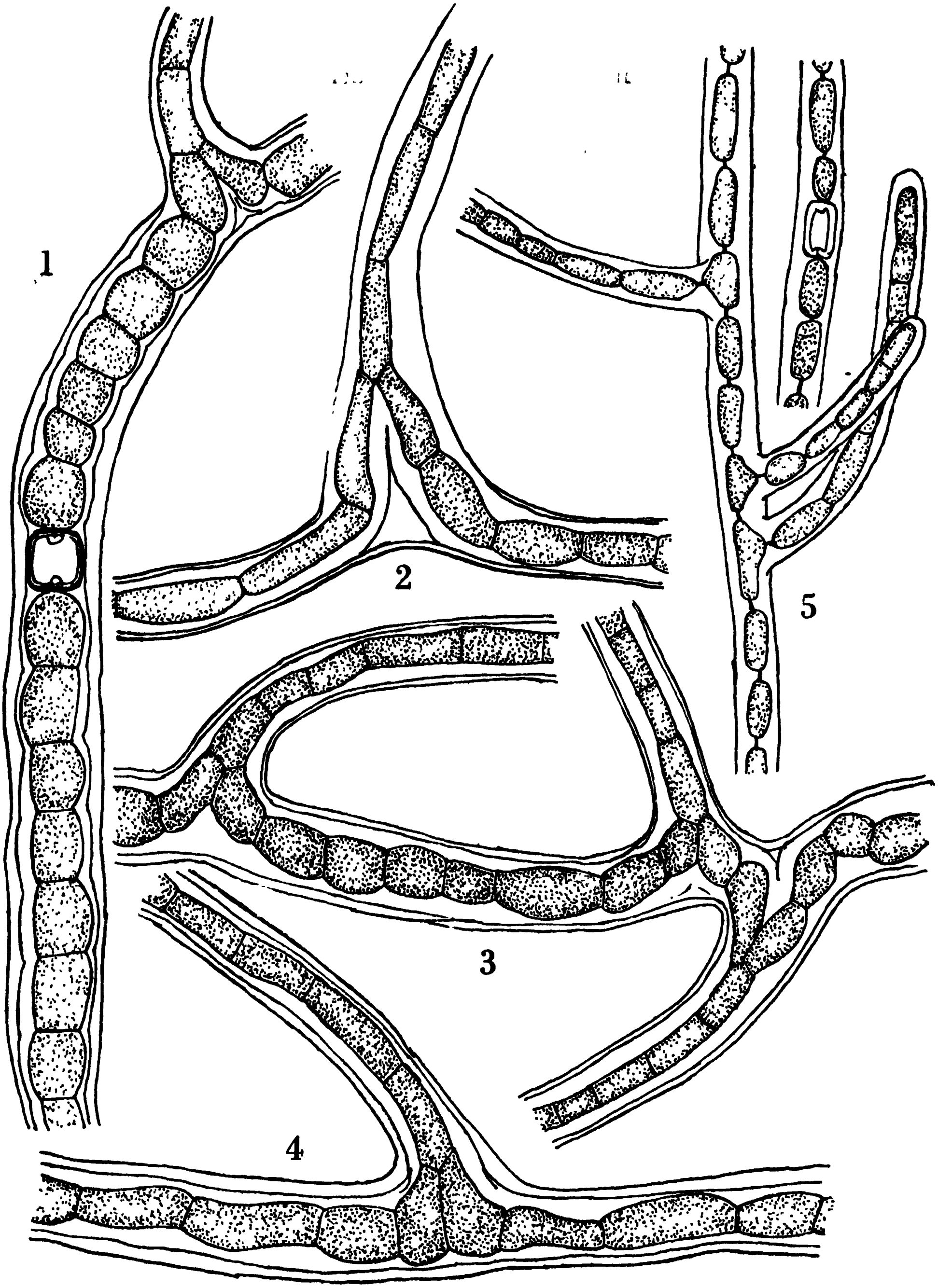

PLATE 126, Figs. 1–5.

1–4. *Mastigocladus laminosus* v. *indica* v. nov. (orig.); 5. *Hapalosiphon delicatulus* West et West (orig.).

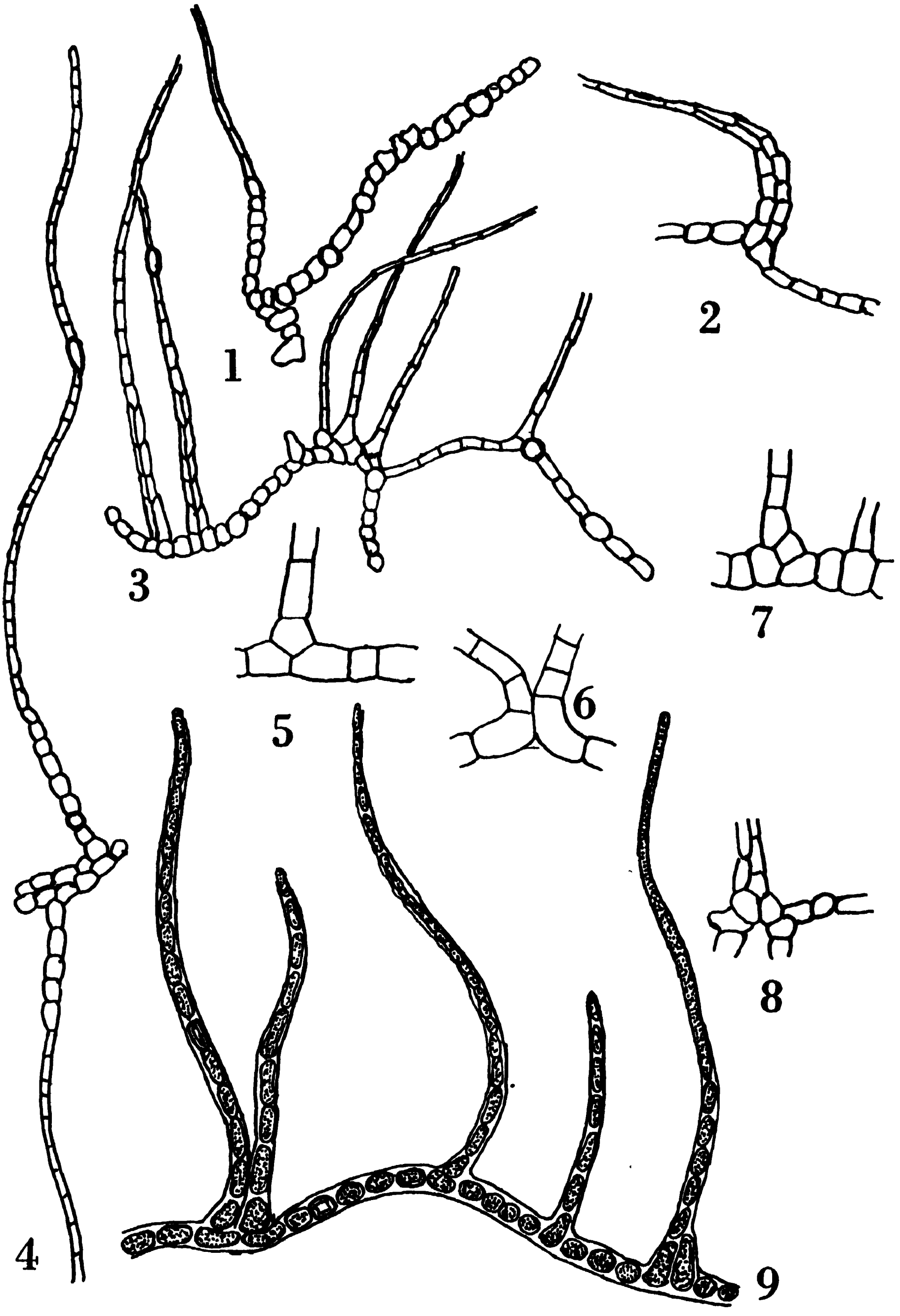

PLATE 127, Figs. 1–9.
*Mastigocladus laminosus* Cohn (1–4, 8 after Rabenhorst, 5–7 after Geitler, 9 after Frémy).

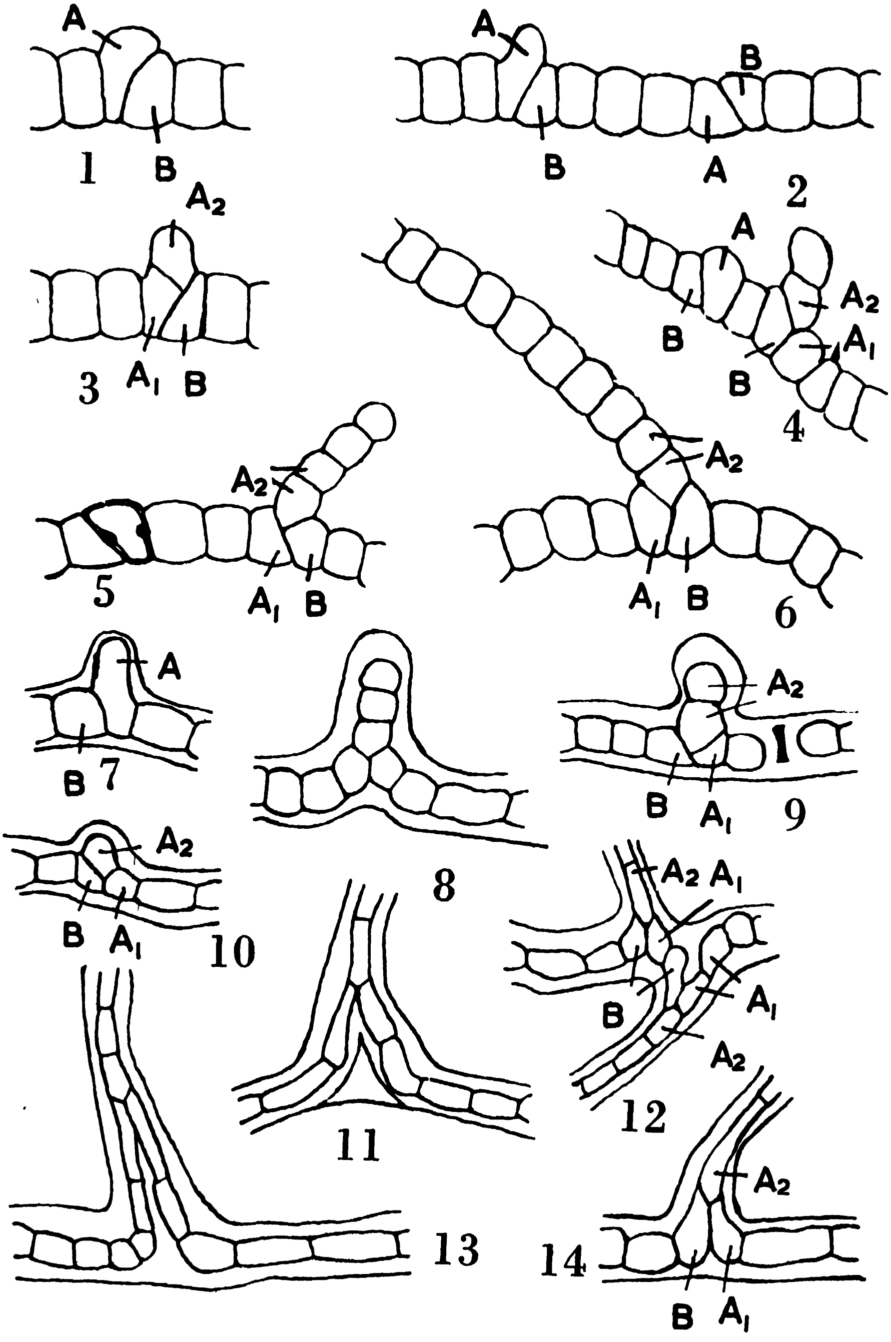

PLATE 128, Figs. 1–14.

Mode of reverse 'V'-shaped branching in *Mastigocladus* spp.; 1–6. *Mastigocladus sp.* (after Iyengar and Seshadri, orig.); 7–14. *Mastigocladus laminosus* v. *indica* var. nov. (orig.).

Thallus made of free variously bent filaments; filaments irregularly laterally branched with one or more rows of cells; often with main and lateral filaments; lateral branches short with longer cells, often growing erect and forming hormogones; main filaments often prostrate, often forming spores or in a chroococcaceous stage growth of filaments by the division of an apical cell; branch initiation by the longitudinal division of the parent cell; heterocysts intercalary or lateral and sessile, pedicellate heterocysts absent; hormogonia present; spores and hormocysts occasionally present.

### KEY TO THE GENERA

1. Erect system made of a single erect trichome ending in a hair .. *Iyengariella* (p. 598)
1. Erect system not so ........ 2
    2. Filaments crescent shaped, sparsely branched........ *Camptylonema* (p. 596)
    2. Filaments not so ........ 3
3. Older filaments more or less with many rows of cells ........ 5
3. Older filaments with a single row of cells or many rows only for short portions..... 4
    4. Lateral branches not much different from the main filament........ 7
    4. Lateral branches distinct from the main filament ..... *Fischerella* (p. 599)
5. Filaments prostrate without a distinct erect system ........ *Stigonema* (p. 603)
5. Filaments prostrate with distinct lateral branches found on the upper portion...... 6
    6. Hormogones formed on distinct short lateral branches .. *Fischerellopsis* (p. 603)
    6. Hormogones formed on ordinary laterals ........ *Fischerella* (p. 599)
7. Hormocysts present ........ *Westiella* (p. 594)
7. Hormocysts absent ........ 8
    8. Hormogones present ........ *Hapalosiphon* (p. 585)
    8. Hormogones not known, endospores present ........ *Westiellopsis* (p. 596)

## HAPALOSIPHON Näg.

in Kützing, Species Algarum, 894, 1849; Bornet and Flahault, Revision des Nostocacées hétérocystées, 54, 1887.

Thallus caespitose, floccose, thin, aquatic; filaments free, not coalescing laterally; cells in one or two rows, sheath present, continuously branched; branches irregularly lateral, true, often arising only on one side of the filaments, false branches present, branches erect from the primary prostrate filaments, erect branches as broad as and similar to the main filament; heterocysts intercalary, only occasionally lateral; hormogones formed mostly from the side branches; spores present.

Type species: *H. fontinalis* (Ag.) Born. ( = *H. pumillus* Kirchner; = *H. braunii* Näg.).

Geitler (1925, p. 212; 1936, fig. 51; Frémy, 1936, fig. 1 (d$_1$–d$_4$),) have described the branch formation in *Hapalosiphon*. Branching has been studied by Iyengar and the writer in a number of species. Intercalary division is quite common in the alga and branches arise generally from newly divided cells. In these cells the contents are generally richer. A cell in the main filament divides transversely and one or both the daughter cells form lateral branches. At first a protuberance is formed which is cut off by a wall which is parallel to the longitudinal axis of the parent filament. The mode of branching described here agrees with the accepted mode of lateral branch formation in *Hapalosiphon.* In some cases the cell may divide repeatedly to form a number of smaller cells rich in contents and one or more of these may develop into branches. As the branch is growing forward it secretes its own sheath and the first beginnings of the sheath can be seen inside the main filament even when the protuberance is formed, so that the limits of the original cell from which the branch is formed is clearly indicated, by the lower portions of the sheath of the branch inside the parent filament. The cell in the main filament has generally a tendency to elongate a little at the place of its attachment with the branch in the direction of the branch. In some cases, e.g., *Hapalosiphon intricatus* (collected from Kambakkam, Madras State), the cell in the main filament after forming a branch may divide by a transverse division or an oblique division into two unequal cells; the larger cell bears the branch and the other lies as a small cell at its side. This tendency for the branch forming cell to divide after the formation of the branch was seen rarely also in *H. delicatulus* collected from Tirupati in Andhra State. In a *Hapalosiphon* sp., collected from Adyar a cell in the parent filament divides into two daughter cells, in some by transverse division and in others by a distinctly oblique division. In the case of transverse divisions both the cells formed by the transverse division may form branches as in other species. But in the case of the two daughter cells formed by the oblique division only one of the daughter cells forms a branch.

Typical false branches are also seen, sometimes commonly, in many species of *Hapalosiphon* and is formed just like those of the Scytonemataceae.

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Sheath colorless | 2 |
| 1. | Sheath colored | 10 |
| 2. | Lateral branches short | 3 |
| 2. | Lateral branches long | 6 |
| 3. | Main filament 5.5–7.5 μ broad | 1. *H. welwitschii* (p. 588) |
| 3. | Main filament broader | 4 |
| 4. | Filaments about 8 μ diam. | 2. *H. hansgirgi* (p. 590) |
| 4. | Filaments up to 10 μ diam. | 5 |
| 5. | Lateral branches flagelliform (?) or attenuated | 3. *H. flagelliformis* (p. 590) |
| 5. | Lateral branches not attenuated | 4. *H. baronii* (p. 591) |
| 6. | Main filaments 3–4.2 μ broad | 5. *H. delicatulus* (p. 591) |
| 6. | Main filaments broader | 7 |
| 7. | Main filaments 4–7.2 μ broad | 6. *H. intricatus* (p. 591) |
| 7. | Main filaments broader | 8 |
| 8. | Filaments 7.2–9.5 μ broad | 9 |
| 8. | Filaments (8–) 12–24 μ broad | 7. *H. fontinalis* (p. 592) |

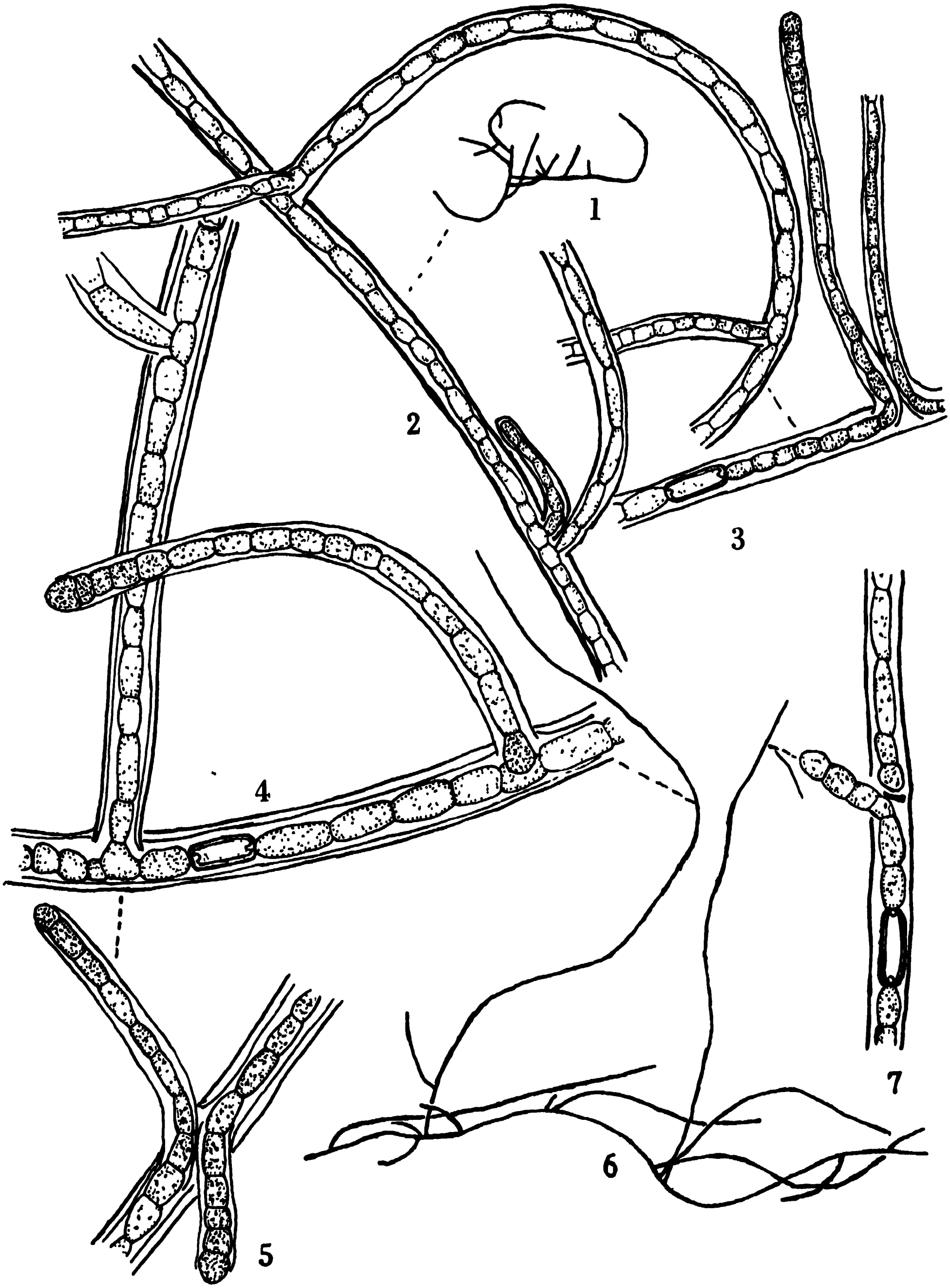

PLATE 129, Figs. 1–7.

1–3. *Hapalosiphon intricatus* West et West (orig.); 4–7. *H. stuhlmannii* Hieron. (orig.).

9. Sheath thin .......................................... 8. *H. hibernicus* (p. 593)
9. Sheath thick .......................................... 9. *H. stuhlmannii* (p. 593)
    10. Side branches narrower than the main filament; main filaments (8–) 12–24 μ broad .......................................... 7. *H. fontinalis* (p. 592)
    10. Side branches as broad as the main filament; main filament 9.5–11.5 μ broad 10. *H. luteolus* (p. 593)

### 1. **Hapalosiphon welwitschii** W. et G. S. West

J. Bot., Lond., 35: 242, 1897; Freshwater algae from Burma including a few forms from Bengal and Madras, Ann. Roy. bot. Gdn., Calcutta, 6: 240, 1907; Forti in De Toni, Sylloge Algarum, 5: 572, 1907; Frémy, Myxo. d'Afr. équat. franc., 420, fig. 338, 1929; Geitler, Kryptogamenflora, 531, fig. 328a, 1932.

Pl. 137, Fig. 5

Filaments single among other algae, somewhat flexuous, 5.5–7.5 μ broad; sheath very close, hardly visible, colorless; cells subspherical or elongate, as long as broad or longer; lateral branches short, as broad as the main filament or narrower, 3.5–5.7 μ broad, slightly attenuated at the ends; cells of the branches ½–3 times as long as broad; heterocysts rare, intercalary, quadrate rounded or long cylindrical, 6 μ broad, 6–8 μ long; spores subspherical or oblong, 5 μ broad, 1–2 times as long as broad.

In a marshy open place in forest, Mansang, near Hsipaw, Burma (West and West, 1907, 240); in paddyfield soil cultures, Goregaon, Bombay (Gonzalves and Gangla, 1949, 54).

Rao, (Myxophyceae of the United Provinces, III, Proc. Indian Acad. Sci., B, 6: 349, fig. 3 C and D, 1937b) describes a form.

Pl. 130, Figs. 4, 5

Plant mass terrestrial, dark green; filaments closely entangled sheath thin, firm and hyaline; cells spherical, quadrate or longer than broad, 3–7.5 μ broad, rarely 9 μ broad, 4.5–15 μ rarely 16.8 μ long; branches short and narrower than the main axis, 3–6 μ broad and 2.2–16.5 μ long; heterocysts rare, long cylindrical, 4.5–7 μ broad and 7.5–10 μ long; spores more or less spherical or longer than broad, 6–12 μ broad and 5.2–12.5 μ long.

On moist bricks at the edge of a rainwater pool, Benaras (Rao, *loc. cit.*).

### Var. **vaginatus** Ghose

The Myxophyceae of Rangoon, II, J. Burma Res. Soc., 17: 241, pl. 2, fig. 11, 1927b.

Filaments sparse, creeping among other algae, slightly flexuous 7–10 μ broad, branches unilateral or distichous, short long, and subbranched; sheath

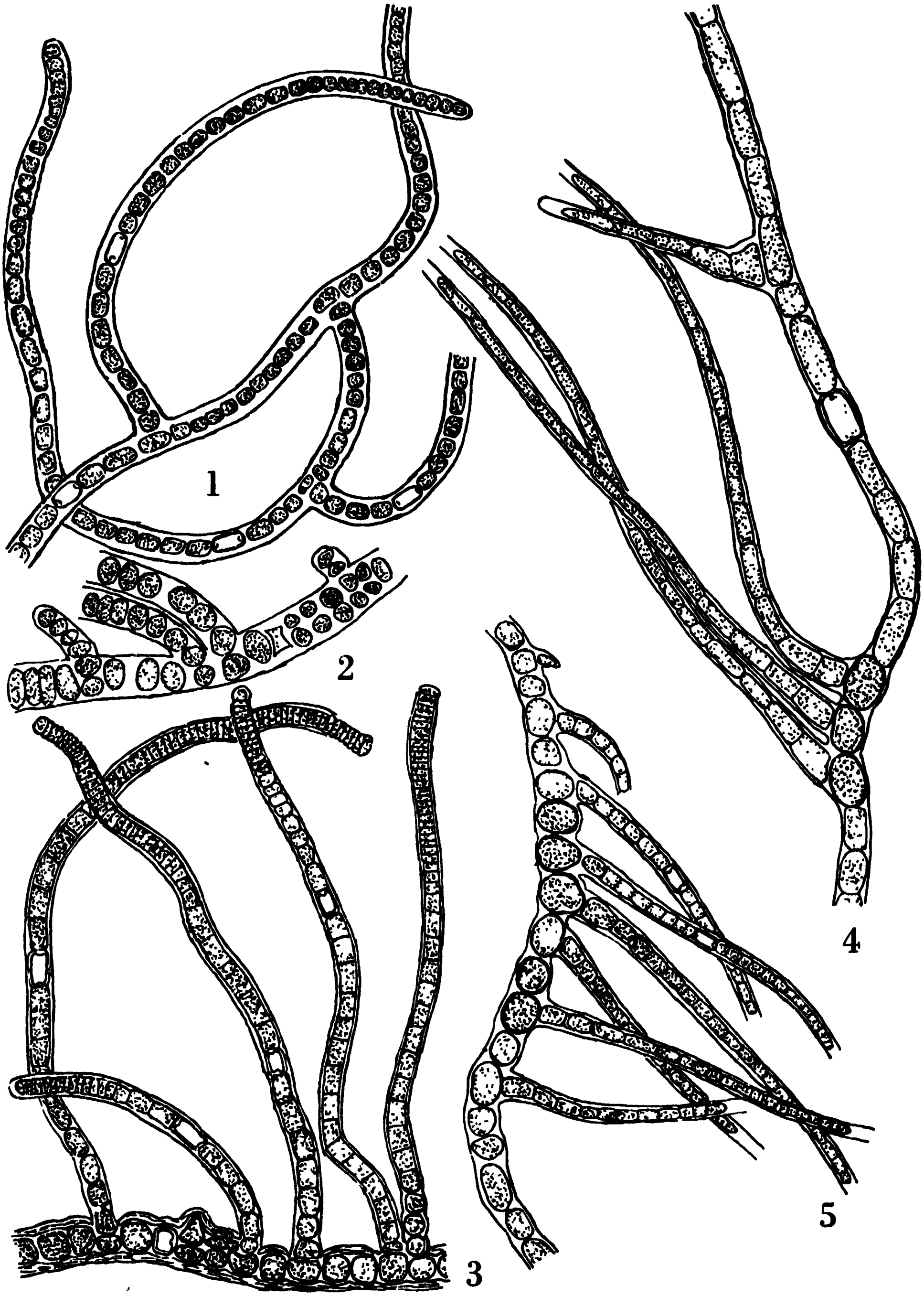

PLATE 130, Figs. 1–5.

1. *Hapalosiphon luteolus* West et West (after Frémy); 3. *H. fontinalis* (Ag.) Born. (after Frémy); 4, 5. *H. welwitschii* forma (after Rao, C. B.); 2. *Fischerella epiphytica* Ghose (after Ghose).

colorless, but distinct; cells 6–9 μ thick, globose quadrate or oval; heterocysts seen only in younger filaments, intercalary ones rare, 6 μ broad and 6.5 μ long; spores not seen.

Victoria lakes near the banks, Rangoon (Ghose, *loc. cit.*).

### 2. **Hapalosiphon hansgirgi** (Schmidle) Forti

in De Toni, Sylloge Algarum, 5: 567, 1907.

= *Mastigocladus hansgirgi* Schmidle, Einige neue Prof. Dr. Hansgirg in Vorderindien gesammelte Süsswasseralgaen, Allg. bot. Zeitschr., 6: 54, 1900a; Über einige von Prof. Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 176, pl. 9, figs. 13–16, 1900b.

Thallus papyraceous, mostly single layered, pale blue green; filaments irregularly intricate and curved, sometime parallel, cylindrical; filaments 8 μ diam., narrowing down to about 5 μ, occasionally not branched, rarely false branched, branches short, without sheath; sheath hyaline, mucilaginous; trichome blue green, 6–8 μ diam., cells isodiametric or half as long as broad, at first cylindrical, later torulose, contents granular.

In stagnant waters near Matunga and Parel, near Bombay (Schmidle, *loc. cit.*).

Kisselev (Eine neue Blaualge *Scytonematopsis woronishinii* mihi J. Soc. bot. de Russie, 15: 169–175, 1930; *see* also Elenkin, 1949, p. 1209–1210) places this species under *Scytonematopsis*.

### 3. **Hapalosiphon flagelliformis** (Schmidle) Forti

in De Toni, Sylloge Algarum, 5: 567, 1907;

= *Mastigocladus flagelliformis* Schmidle, Einige neue von Prof. Dr. Hansgirg Vorderindien gesammelte Süsswasseralgen, Allg. bot. Zeitschr., 6: 53, 1900a; Über einige von Prof. Hansgirg in Östiendien gesammelte Süsswasseralgen, Hedwigia, 39: 175, pl. 10, figs. 13–18, 1900b.

Pl. 119, Figs. 3, 5–7

Thallus in spots or patches always mucilaginous, blackish green, small; filaments about 10 μ broad, torulose; sheath thin, hyaline, rarely pale yellowish; contents homogeneous, blue green; cells elliptic, to rounded, isodiametric or longer or rarely shorter, simple rarely with cells in two series in the main filament, branches in one direction up to ½ mm long, main filaments at the base about 6 μ diam., cells rectangular, 1½–3 times as long as broad, apex only 2 μ, with very little protoplasm, short branches whip like, in appearance; heterocysts oblong, large, ventricose, in the longer branches at frequent intervals, broader than the trichome, sheath inconspicuous, filaments and branches intertwined, fragile, parallelly arranged later, sheath mucilaginous diffluent or periphery irregularly agglutinated; filaments torulose, cells like big gonidia, with enclosing membrane.

On moist rocks between Neral and Matheran, near Bombay (Schmidle, *loc. cit.*).

4. **Hapalosiphon baronii** W. et G. S. West

Freshwater Algae of Madagascar, Trans. Linn. Soc. Bot., Lond., 5: 85, pl. 5, figs. 21–24, 1895; Forti in De Toni, Sylloge Algarum, 5: 568, 1907; Frémy, Myxo. d'Afr. équat. franc., 429, fig. 343, 1929; Geitler, Kryptogamenflora, 532, fig. 329, 1932.

Pl. 119, Fig. 2

Thallus caespitose; filaments densely aggregated, richly branched 7.5–10 μ broad; sheath broad, colourless; cells of the lateral branches quadrate, rounded to subspherical, 3.5–5 μ diam., lateral branches short; heterocysts subquadrate.

In a lake, Igatpuri near Bombay (Schmidle, 1900b, 175).

5. **Hapalosiphon delicatulus** W. et G. S. West

Freshwater algae of Ceylon, Trans. Roy. micr. Soc., 6: 203, 1902; Forti, in De Toni, Sylloge Algarum, 5: 571, 1907; Geitler, Kryptogamenflora 532, 1932.

Pl. 126, Fig. 5

Filaments single, between other algae, curved, 3.8–4 μ broad; sheath very thin, colourless; cells 2–3½ times as long as broad, lateral branches as broad as the main filament or a little narrower; cells of the side branches 11–30 times as long as broad; heterocysts 2–3 times as long as broad, 3–3.8 μ broad and 7–12 μ long.

In paddy fields, Henaratgodha, Ceylon (West and West, *loc. cit.*); in a lake at Kodaikanal, ( ! ) and on plants in a pool at Tirupati hills ( ! ).

The South Indian forms are somewhat broader (Filaments 3.9–5.2 μ broad, trichomes 2.6–3.9 μ broad, cells 5.2–13.1 μ long; heterocysts 2.6–3.9 μ broad and 3.9–5.2 μ long).

6. **Hapalosiphon intricatus** W. et G. S. West

Alg. West Indies, J. Linn. Soc. Bot., Lond., 30: 271, pl. 15, figs. 16–28, 1894; Forti in De Toni, Sylloge Algarum, 5: 571, 1907; Frémy, Myox. d'Afr. équat. franc., 422, 1929; Geitler, Kryptogamenflora, 533, fig. 330, 1932.

Pl. 129, Figs. 1–3

Thallus caespitose, blue-green, small, filamently densely interwoven, sparsely branched, 4–7 μ broad; sheath close to the trichome, colourless often indistinct; cells spherical, to cylindrical, 1½–3 times as long as broad; lateral branches as thick as the main filament; heterocysts intercalary, subquadrate to cylindrical, 3.8–5.5 μ broad; spores spherical to ellipsoidal, seldom nearly cylindrical.

Shembaganur, Madras State (Frémy, 1942, 22); Tanuggyi canal and stagnant water, Rangoon (Skuja, 1949, 25); epiphytic on plants in a stream, Kambakkam ( ! ).

The Kambakkam alga is slightly different: — Filaments 3.9–7.9 μ broad, cells 2.6–6.6 μ long; heterocysts 3.5–7.1 μ broad and up to 17.8 μ long.

### 7. **Hapalosiphon fontinalis** (Ag.) Bornet

Bull. Soc. bot. Fr., 36: 156, 1889; Forti in De Toni, Sylloge Algarum, 5: 568, 1907; Frémy, Myxo. d'Afr. équat. franc., 426, fig. 342, 1929; Geitler, Kryptogamenflora, 535, fig. 332, 1932.

= *H. pumillus* Kirchner, Kryptogamenflora von Schlesien, Algen, 231, 187.

= *H. braunii* Näg., in Kützing, Species Algarum, 894, 1849.

Pl. 130, Fig. 3

Thallus floccose, caespitose blue-green or brown, 1–3 mm high; main filaments interwoven, creeping often torulose, richly branched straight or curved, 12–24 μ broad, mostly with one row of cells occasionally in two or three rows; cells quadrate to spherical, mostly as long as broad; sheath more or less thick, colourless or in the older ones yellowish brown; lateral branches erect, thinner than the main filament, 9–12 μ broad, with a thinner sheath; cells in the branches mostly quadrate to cylindrical; hormogones about 6 μ broad, 100–300 μ. long, with 14–50 cells.

On submerged plant parts in stagnant waters, Bengal (Kurz no. 3130 in Herb. Grunow in Born. and Flah., 1887, 61).

Elenkin (1938, p. 504) amends this species and includes in it 10 other species, viz., *H. pumillus* Kirchn., *H. braunii* Näg., *H. Brébissonii* Rab., *H. fuscescens* Borzi, *H. tenuissimus* Grunow, *H. intricatus* W. and G. S. West, *H. hiberaicus* W. and G. S. West, *H. stuhlmannii* Hieron., *H. welwitschii* W. and G. S. West, and *H. luteolus* W. and G. S. West. He creates six other forms in addition to the type to receive some of these species, f. *baculiferus* Elenk., f. *fischeroides* Hansg., f. *hibernicus* (West and West) Elenk., f. *intricatus* (West and West) Elenk., f. *tenuissimus* (Grun.) Collins and Setchell and f. *globosus* Nordst.

Var. **fischeroides** Hansgirg, Notarisia, 398, 1888; Prodromus der Algenflora von Böhmens, 2: 26, 1898; Geitler, Kryptogamenflora, 537, 1932.

Main filament mostly with cells in two rows, seldom in a single row, 8–12 μ broad; branches 6–8 μ broad, trichome 5–6 μ broad, with one row of cells, up to 100 μ long; cells mostly subquadrate to ½ as long as broad; sheath nearly colourless; heterocysts rare in main filament and sparse in branches, quadrate, elliptical to elongate cylindrical.

On sprayed rocks near a waterfall, Tirupati ( ! ).

8. **Hapalosiphon hibernicus** W. et G. S. West

New British freshwater Algae, Trans. roy. micr. Soc., 5: 163, 1896; Forti in De Toni, Sylloge Algarum, 5: 572, 1907; Geitler, Kryptogamenflora, 533, fig. 331, 1932.

Filaments single amidst other algae, somewhat flexuous, 7.2–9.5 μ broad, richly branched, sheath close to the filaments, thin, colourless; cells quadrate rounded to subcylindrical, or shorter than broad; lateral branches erect, thinner than the main filament, 4.5–5.5 μ broad, single or 2–3 side by side, long and sometimes branched again; false branches often seen; cells of the branches 3–4 seldom up to 8 times as long as broad; heterocystis cylindrical, 5 μ broad, 1½–5 times as long as broad.

In stagnant waters, epiphytic. — Kyauktan and Rangoon and its neighbourhood (Skuja, 1949, 25).

The Burmese alga is bigger than the type. — Main filament 7–11 μ broad, side branches 4.5–7 μ broad, gradually attenuated; sheath in older parts up to 1 μ thick, hyaline, when old with parallel lamellation.

9. **Hapalosiphon stuhlmannii** Hieron.

in Engler, Pflanzenwelt Ostafr., Teil, C, 10, 1895; Frémy, Myxo. d'Afr. équat. franc., 429, 1929; Geitler, Kryptogamenflora, 534, 1932.

Pl. 129, Figs. 4–7

Thallus floccose, caespitose, blue-green; filaments intertwined, creeping often torulose, richly branched, up to 10 μ broad; cells mostly one or seldom in two rows, nearly as long as broad, or shorter; sheath seemingly thick, lateral branches erect, 5–8 μ broad, repeatedly branched, with long cylindrical cells, cells up to 16 μ long; heterocysts spherical or oblong, 6–8 μ broad and up to 16 μ long.

Among other algae in a lake at Kodaikanal ( ! ).

The Kodaikanal alga is 6.6–9.2 (–10.5) μ broad, cells 3.9–6.6 μ broad and 5.2–14.4 μ long; heterocysts 5.2–6.6 μ broad and up to 19.6 μ long.

10. **Hapalosiphon luteolus** W. & G. S. West

Welwitsch. Afr. Alg., J. Bot. Lond., 35: 241, 1897; Forti in De Toni, Sylloge Algarum, 5: 570, 1907; Frémy, Myxo. d'Afr. équat. franc., 429, 1929; Geitler, Kryptogamenflora, 537, fig. 333, 1932.

Pl. 130, Fig. 1

Thallus small, caespitose, yellowish brown, densely interwoven, 9.5–11.5 μ broad; lateral branches single, flexuous, sometimes short and straight as broad as and similar in appearance as the main filament, not attenuated; sheath firm, broad, yellowish; cells cylindrical or subquadrate, 5.5–6 μ broad, up to three times as long as broad; heterocysts intercalary, cylindrical, 1½–3 times as long as broad; spores subquadrate or somewhat longer than broad.

Paddy-fields between Kosgoda and Urahaighasmahendai (West and West, 1902, 201) and tycholimnetic in tank Kekunadure near Matara and tank Tibbotuwewa in Ceylon (Crow, 1923b, 143).

## WESTIELLA Borzi

Studi sulle Mixoficee, Nuovo. Giorn. bot. ital., 1122, 1917.

Thallus made up of free, regularly laterally branched filaments; trichomes with a single series of cells: lateral branches sometimes attenuated, main filaments uniformly cylindrical; sheath close to the trichome, homogeneous; heterocysts intercalary; hormogones formed at the ends of branches; hormocysts terminal and intercalary, single or a few together, 2–12 celled; spores present.

Type species: *W. intricata* Borzi.

### KEY TO THE SPECIES

1. Hormocysts 12–16 μ broad with thin sheath ................ 1. *W. intricata* (p. 594)
1. Hormocysts narrower than 12 μ, with thick and lamellated sheath 2. *W. lanosa* (p. 594)

### 1. **Westiella intricata** Borzi

Studi sulle Mixoficee, Nuovo Giorn. bot. ital., 84, pl. 9, figs. 42–43, 1917; Geitler, Kryptogamenflora, 544, fig. 337, 1932.

Pl. 8, Figs. 14–17

Filaments long, creeping amongst other algae, flexuous, irregularly branched, 6–10 μ broad; branches as broad as the main filament, somewhat attenuated at the ends; cells cylindrical up to 1½ times as long as broad or rarely longer; sheath colourless, very thin; heterocysts intercalary, quadrate or elongate, 1–2 times as long as broad; hormocysts with 2–8 cells, 12–16 μ broad with a reddish brown sheath, sheath externally rough.

Along with other algae on the banks of a lake, Rangoon (Ghose, 1927b, 241).

Geitler doubts this record (1932, 544).

### 2. **Westiella lanosa** Frémy

Rev. algol. Paris, 1: 41, figs. 5 and 6, 1924; Myxo. d'Afr. équat. franc., 434, figs. 346, 347, 1929; Geitler, Kryptogamenflora, 544, figs. 338, 339, 27, 1932.

Pl. 136, Figs. 3, 4

Thallus caespitose, up to 2 cm. high, greyish blue-green on the outside, inside more or less colourless; filaments densely arranged straight or flexuous,

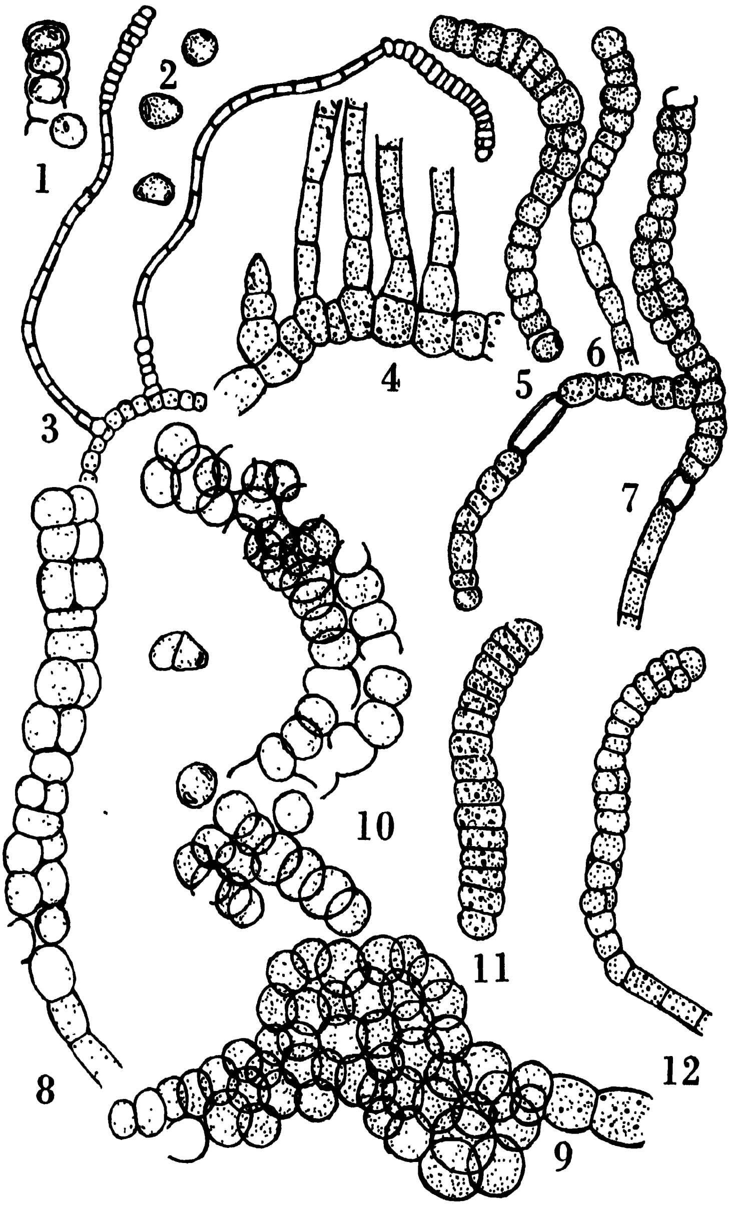

PLATE 131, Figs. 1–12.
*Westiellopsis prolifica* Janet (after Janet).

rregularly branched, 8–10 μ broad; branches mostly single, seldom in two, nearly uniformly as broad as the main filament, long erect, more or less creepng; sheath thin, homogeneous, papyraceous, colourless; trichome pale bluegreen, 7–8 μ broad, cylindrical at the end sometimes attenuated; cells nearly quadrate or longer than broad, up to 20 μ long; heterocysts 8–9 μ broad up to 14 μ long, seldom nearly quadrate; hormogones up to 40 μ long; hormocysts up to 40 μ long, 2–12 celled, 12 μ broad, with a thick, yellowish or reddish brown smooth sheath; spores ellipsoidal, 6 μ broad, 7 μ long, single or up to four in series, terminal or intercalary with a smooth brown wall.

Cultures of paddy-fields soils, Thana near Bombay (Gonzalves and Gangla, 949, 53).

### WESTIELLOPSIS Janet

*Westiellopsis prolifica* gen. et. sp. nov., a new member of the Stigonemataceae. Ann. Bot., Lond., n. s. 5: 167–170, 1942.

Thallus filamentous with true branching filaments of two kinds, primary filaments slightly thicker and more or less creeping, secondary filaments generally thinner and growing erect, filaments without a sheath and consisting of a single row of cells; heterocyst intercalary; the dilated terminal portions of secondary branches by profuse transverse and longitudinal divisions forming chains of rounded cells (Pseudohormocysts), the contents escaping as gonidia endospores) and develop as into new plants.

Monotypic: *W. prolifica* Janet.

#### **Westiellopsis prolifica** Janet

Ann. Bot., Lond., n. s., 5: 167–170, 1942.

Pl. 131, Figs. 1–12

Main filaments torulose, with short barrel-shaped cells, 8–12 μ broad as long as broad, or slightly longer, branch filaments thinner and elongate, not constricted at the cross-walls, with elongate cylindrical cells, 4–6 μ broad; heterocysts oblong-cylindrical, 5.5–6 μ broad and 10.5–22 μ long; gonidia formed singly in each cell of the pseudohormocysts, 8.5–9 μ diam.

In cultures of soil from a garden, Madras. (Janet, *loc. cit.*).

### CAMPTYLONEMA Schmidle

Ueber einige von Prof. Dr. Hansgirg in Östindien gesammelte Süsswasseralgen, Hedwigia, 39: 181, 1900b.

= *Schmidleinema* De Toni, J., Joterelle di nomencl., 8: p. 6, 1936.

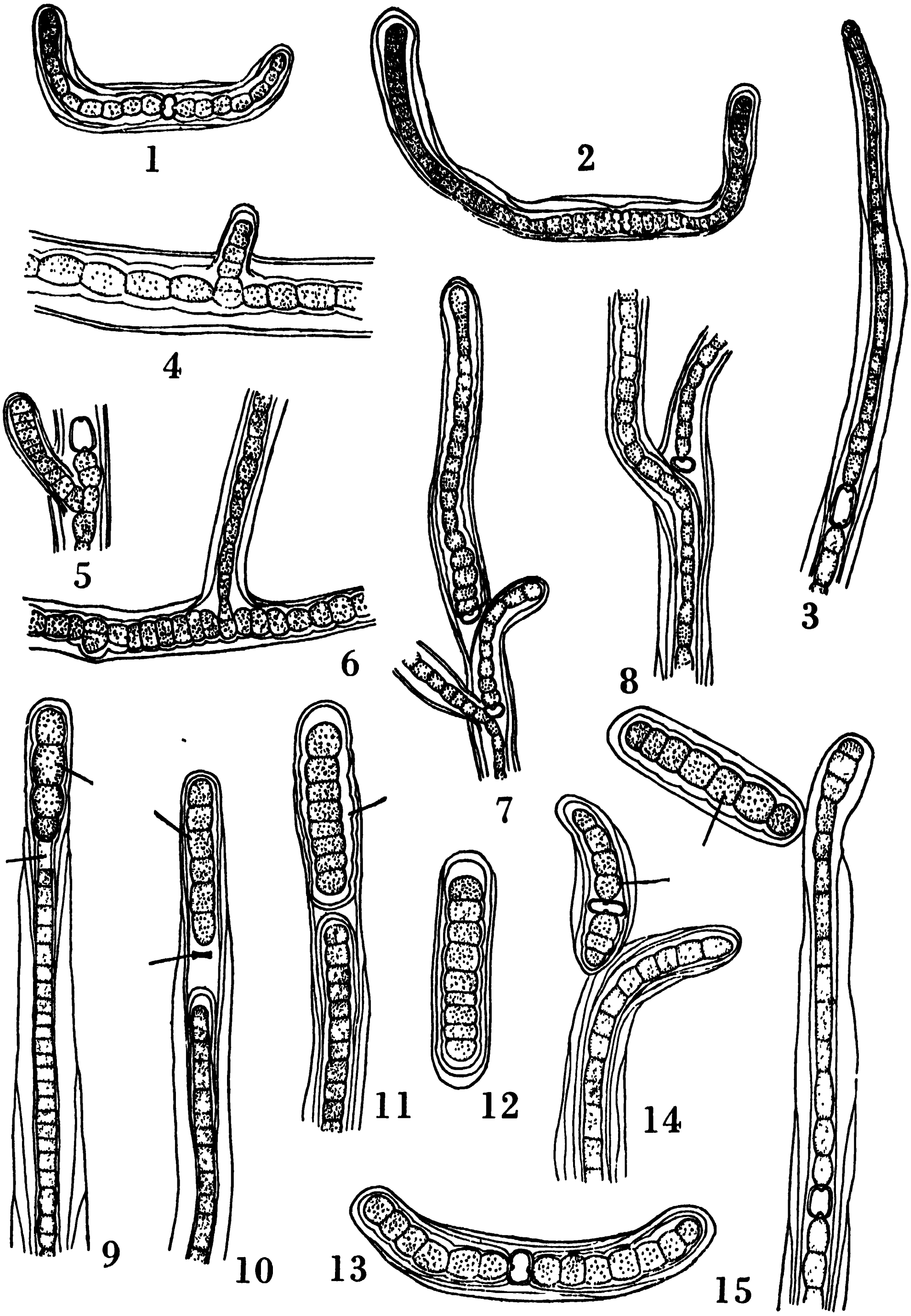

PLATE 132, Figs. 1–15.
*Camptylonema indicum.* Schmidle (after Desikachary).

Filaments more or less semicircularly bent with a middle prostrate portion and both ends growing up; branching sparse, both true and false branching present; heterocysts intercalary or basal near a false branch; hormocysts apical, either single or a few formed in succession.

Type species: *C. indicum* Schmidle.

For a long time the presence of true branches in *Camptylonema* was doubted. Desikachary (1948) has reported the type of the genus for a second time from India and showed very clearly that it is one of the Stigonemataceae.

Geitler (1942) placed it in the Borzinemataceae along with *Borzinema, Seguenzaea, Handeliella,* and *Spelaeopogon.* He placed *Camptylonema* at the end of this family under ' Anhang '. *Camptylonema* resembles *Handeliella* so much that it may even be questioned whether both are not identical.

### **Camptylonema indicum** Schmidle

Hedwigia, 39: 161, 1900b; Desikachary, On *Camptylonema indicum,* and *Camptylonemopsis* gen. et sp. nov., Proc. Indian Acad. Sci., B, 28: 35, figs. 1–15, 1948.

= *Campylonema indicum* Schmidle, Forti in De Toni, Sylloge Algarum, 5: 540, 1907; Geitler, Kryptogamenflora, 705, 1932.

= *Stigonema indica* Schmidle, Allg. bot. Zeitschr., 34, 1900a.

= *Schmidleinema indicum* (Schmidle) De Toni, J., Noterelle di nomencl. algol., 8: 6, 1936.

Pl. 132, Figs. 1–15

Plant mass brownish; filaments crescent shaped, in the middle portion 13.1–15.7 μ broad and in the erect portions (7.9–) 9.2–11.8 μ broad; sheath lamellate, yellowish brown; branching rare, true and false branches present, true branches generally arising in the prostrate middle portion and the false branches from the erect portions; trichomes torulose in the middle portion and unconstricted or slightly constricted in the erect branches; cells 7.9–11.8 μ broad and 3.9–9.2 μ long in the prostrate region and 3.9–6.6 μ broad and 7.9–18.3 μ long in the erect portions; heterocysts intercalary, as broad as the trichomes, as long as broad or slightly longer; hormocysts formed apically consisting of 4–12 cells, with a thick lamellated brownish sheath.

On tree trunks, Mahim near Bombay (Schmidle, 1900a, 1900b); on moist walls of a house, Ernakulam (Desikachary, 1948).

## IYENGARIELLA Desikachary

Phytomorphology, 3: 249–253, 1953.

Thallus attached, in tufts, habit heterotrichous with a lower branched prostrate portion and an upper unbranched free erect portion, branching true, simple and lateral or pseudodichotomous; sheath present; trichome consisting of a single series of cells, apex produced into a long hair; heterocysts absent; hormogones present; spores present.

Monotypic.

### **Iyengariella tirupatiensis** Desikachary

Phytomorphology, 3: 249–253, figs. 1–25, 1953.

Pl. 133, Figs. 1–18

Thallus attached in tufts; heterotrichous, with a branched prostrate region and a free erect portion; branching ture, simple and lateral, pseudodichotomous; filaments in the prostrate region 10–20 μ broad, sheath present enclosing generally one sometimes more filaments, thick, lamellated in the lower portions, divergent; trichome uniseriate, broader, in the lower portions and tapering to a hair at the apex, 3–10 μ broad at the base and 1–3 μ in the apical portion; cells shorter than broad below and up to ten times as long as broad above; heterocysts absent; hormogones present; spores spherical or subspherical, 4.5–6 μ broad.

On rocks in mountain stream, Tirupati (Desikachary, 1953) and Pachmarhi in Madhya Pradesh (Desikachary and Mall, 1955).

## FISCHERELLA (Born. & Flah.) Gomont

J. de Bot., 9: 52, 1895.

Thallus creeping, most of it or only portions with only portions of filaments with cells in many rows, seldom filaments with a single row of cells, erect branches only on one side; lateral branches with long and narrow cells, main filaments with large spherical cells; sheath in young lateral branches thin and close to the trichome, sheath in the older filaments thicker; cells of old filaments often with *Gloeocapsa* like sheath; heterocysts intercalary or lateral; hormogones from the ends of side branches; spores known in some species.

Type species: *Fischerella thermalis* (Schwabe) Gom. ( = *Fischera thermalis* Schwabe; = *Scytonema thermalis* Borzi).

### KEY TO THE SPECIES

1. Main filament mostly with many rows of cells .......... 2
1. Main filament mostly with cells in a single row .......... 3. *F. ambigua* (p. 601)
    2. Main filaments 15–20 μ broad, branches 11–14 μ broad .......... 1. *F. epiphytica* (p. 601)
    2. Main filament about 10 μ broad, branches 4–6 μ broad .......... 2. *F. muscicola* (p. 601)

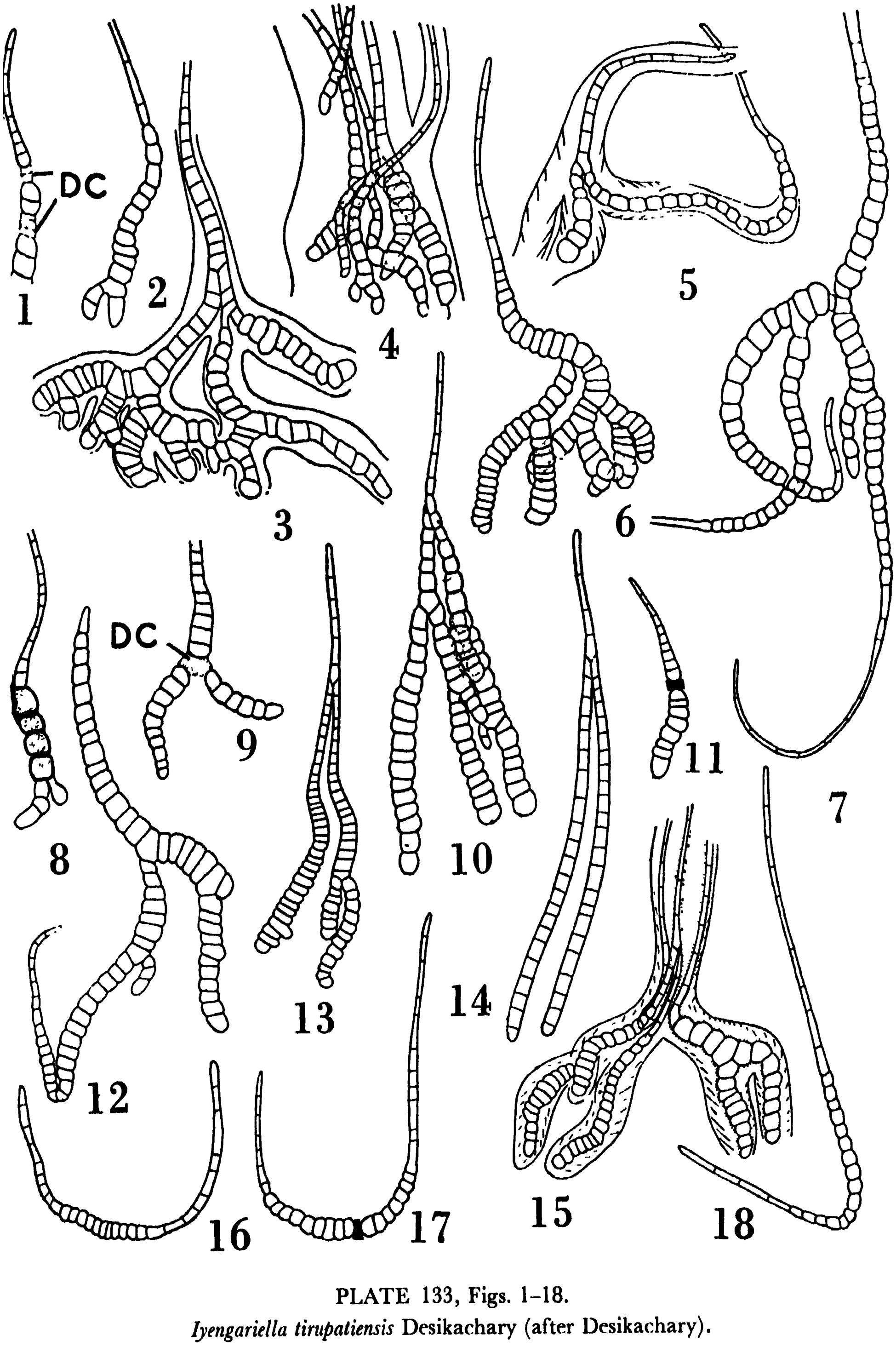

PLATE 133, Figs. 1–18.
*Iyengariella tirupatiensis* Desikachary (after Desikachary).

### 1. **Fischerella epiphytica** Ghose

On a collection of Myxophyceae from Mergui and other neighbouring islands, J. Burma Res. Soc., 17: 246, pl. 3, fig. 4, 1927c; Geitler, Kryptogamenflora, 485, fig. 292, 1932.

Pl. 130, Fig. 2

Thallus crustaceous, felt-like, expanded dark brown; primary filaments creeping, interwoven, 15–20 μ thick, mostly biseriate; cells somewhat spherical or compressed; sheath close to the trichome, brownish; branches erect, cylindrical, 11–14 μ in diam., unilateral, cells globose, separated; heterocysts rare, intercalary; hormogones 2–6 celled.

On the barks of various trees (Mergui island, Medaw island, Burma (Ghose, *loc. cit.*).

### 2. **Fischerella muscicola** (Thuret) Gom.

J. de Bot., 9: 67, 1895; Forti in De Toni, Sylloge Algarum, 5: 575, 1907; Geitler, Kryptogamenflora, 487, fig. 294, 1932.

Main filaments creeping, torulose, flexuous interwoven, forming a thick blackish brown thallus, filaments about 10 μ broad, mostly with two rows of cells; cells subquadrate, subspherical, 7.5 μ diam; sheath of the main filament, close to the trichome, thin, brown; lateral branches erect, more or less straight, 6 μ broad, with a thin colourless or yellowish sheath, with false branches; hormogones present; cells of the lateral branches subquadrate or shorter than broad, blue green; heterocysts subspherical, mostly smaller than the vegetative cells; hormogones long, sometimes club-shaped, 4 μ broad, 100 μ long.

In cultures of soils from paddy fields, Faridpur, Bengal (Banerji, 1935, 298); paddy fields near Allahabad (Gupta, 1953, 306).

Mitra (1951, 360 and 363) mentions a new variety of (var. *indica, nomen nudum*) from cultures of soil (uncultivated, cultivated rice fields, and partially reclaimed Usar soils, from Allahabad, and red soils near Madras).

### 3. **Fischerella ambigua** (Näg.) Gom.

J. de Bot., 9: 52, pl. 3, figs. 1–7, 1895; Forti in De Toni, Sylloge Algarum, 5: 576, 1907; Frémy, Myxo. d'Afr. équat. franc., 446, fig. 351, 1929; Geitler, Kryptogamenflora, 490, fig. 297, 1932.

Pl. 136, Fig. 2

Main filament creeping, variously bent, densely interwoven, 6–9 μ br., within thick, broad, yellowish brown sheath; cells subspherical or cylindrical, 3–4 μ broad; branches erect, curved, 6–9 μ broad, with a broad, colourless or yellowish brown sheath, fasciculate; cells of the branches cylindrical, at the apex quadrate 2–3 μ broad; heterocysts cylindrical; hormogones very long.

Cumballa Hill, India (Schmidle, 1900b, 161); paddy field, Heneratgodha in Ceylon (West & West, 1902, 202).

Playfair (Plankt. of Sydney Water Supply, p. 533, pl. 56, fig. 13d, 1912) transfers this to *Scytonema* (*S. mirabile* v. *ambiguum* (Kütz.) Playfair; = *Scytonema ambiguum* Kütz.).

## SPECIES INQUIRENDA

### **Fischerella tenuis** (Martens) Forti

in De Toni, Sylloge Algarum, 5: 576, 1907;

= *Fischera tenuis* Martens, A fourth list of Bengal, J. asiatic Soc., Bengal, 39: 259, 1870b.

= *Stigonema tenue* (Martens) Bornet and Flahault, Revision des Nostocacées hétérocystées, 67, 1887.

Filaments in primary branches subtorulose, thin; branches 5 μ broad, acuminate, cells above up to twice as long as broad, colour light orange coloured.

On the damp walls of a building, Calcutta (Martens, *loc. cit.*).

## SPECIES DELENDAE

*Fischerella anomala* Bharadwaja, 1933b, 246. (*nomen nudum*).

*Fischerella muscicola* var. *indica* Mitra, 1951, 360/362 (*nomen nudum*).

## APPENDIX TO THE GENUS *FISCHERELLA*

### **Seguenzea anthonyi** Gupta

A new species of *Seguenzea* (*S. anthonyi* sp. nov.), Trans. and Proc. bot. Soc., Edinb., 36(4): 317–319, 1955.

Pl. 139, Figs. 1–6

Thallus cushion-like, bluish or dark bluish, 1 mm height, differentiated into creeping and erect filaments; prostrate filaments 8–18 μ broad, compact, contorted, sheath 1–4 μ thick, often distinctly striated and yellowish or yellowish brown when old; cells of the prostrate filaments 6–10 μ broad, 2.5–7.5 μ long; erect filaments 3–6.5 μ broad, sheath thin and firm, cells 2–6 μ broad, 4–8 μ long; heterocysts and spores absent.

In a rice field, India (Gupta, *loc. cit.*).

It is doubtful whether this alga is not a *Fischerella*.

## FISCHERELLOPSIS Fritsch

Contributions to our knowledge of British Algae, J. Bot., Lond., 70: 129, 1932.

Filaments single or in fascicles arranged parallel within a common gelatinous diffluent sheath; trichomes with club shaped apices and branches; lateral branches formed by the longitudinal division of a cell in the middle part of the trichome, numerous or few, branches short or long, rarely branched; trichome in the middle of the filaments prominently constricted, cells quadrate; trichomes in the branches not constricted, cells elongate; heterocysts single in the main filaments and in the branches, short; hormogonia profusely formed and liberated from the apex of the sheath; spores intercalary, subspherical.

Lectotype: *F. harrisii* Fritsch.

### **Fischerellopsis moniliforme** (Frémy) Fritsch

Contrib. Knowl. Brit. Algae, J. Bot., Lond., 70: 129, 1932.

= *Fischerella moniliformis* Frémy, Myxo. d'Afr. équat. franc., 440, figs. 348–50, 1929.

Primary filaments single, false branches rare; lateral branches are similar and often short clavate; heterocysts absent, hormones single; sheath of lateral branches when mature commonly ocreate; spores single, spherical or ellipsoidal; primary filaments 16–24 (rarely 30) μ broad, cells 12.5–15 μ broad, 6–12 μ long; branches 12–16 μ broad, cells 8–12 μ broad, 4–8 μ long; hormogones claviform, terminal up to 1000 μ long, 8 μ broad at the base and 10–11 μ at the apex; spores intercalary, subspheri 18–24 μ in primary filaments and about 16 μ broad in the lateral branches, not contiguous with the heterocysts, epispores thick, smooth and yellowish.

Among other algae on dripping rocks near Gundar falls, Kodaikanal.

The present alga is slightly different in the habitat and in the dimensions (Fil. 27.8–36.7 (41.9) μ broad, branches 19.6–26.2 (31.7) μ br., cells 10.5–15.7 and 6.5–13.1 μ long in the main fil., and 6.5–10.5 μ br. × 5.2–10.5 μ long in the branches and heterocysts 20.9–22.3 × 9.2–13.1 μ.)

## STIGONEMA Ag.

Systema Algarum, 20, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 62, 1887 (excl. *Fischerella* Born. and Flah.).

Thallus of free irregularly laterally branched, variously curved filaments in older parts with two to many rows of cells; sometimes with apical growth and division; lateral branches like the prostrate parent filaments and as many rows of cells as the main filaments; sheath when young close to the trichome, in older ones broader; old filaments with *Gloeocapsa*-like sheath and cell grouping; heterocysts intercalary or lateral; hormogonia formed at the end of young branches, two to a few celled, seldom many celled.

Type species: *Stigonema mamillosum* Ag.

Geitler (1942, p. 125), includes only about eight species in the genus.

## KEY TO THE SPECIES

| | | |
|---|---|---|
| 1. | Filaments with many rows of cells | 2 |
| 1. | Filaments with many rows of cells | 6 |
| 2. | Filaments generally with a single row of cells | 3 |
| 2. | Filaments often with more than one row of cells | 4 |
| 3. | Filaments 7–15 μ broad | 1. *St. hormoides* (p. 604) |
| 3. | Filaments 25 μ broad | 2. *St. aerugineum* (p. 606) |
| 4. | Filaments with lamellated sheaths | 5 |
| 4. | Filaments without thick lamellated sheaths 14–38 μ broad | 3. *St. tomentosum* (p. 606) |
| 5. | Filaments 24–26 μ broad | 4. *St. panniforme* (p. 606) |
| 5. | Filaments 24–45 μ broad | 5. *St. ocellatum* (p. 607) |
| 6. | Filaments broader than 40 μ | 10 |
| 6. | Filaments narrower | 7 |
| 7. | Filaments in a coralloid thallus | 6. *St. mesentericum* (p. 607) |
| 7. | Filaments not forming such a thallus | 8 |
| 8. | Filaments 27–37 μ broad | 7. *St. turfaceum* (p. 609) |
| 8. | Filaments otherwise | 9 |
| 9. | Filaments with attenuated ends, 16–22 (–25) μ broad | 8. *St. dendroideum* (p. 609) |
| 9. | Filaments 18–28 μ broad | 9. *St. minutum* (p. 611) |
| 10. | Filaments 50–55 μ broad, hormogones short | 10. *St. lavardei* (p. 611) |
| 10. | Filaments broader, hormogones longer | 11 |
| 11. | Hormogones on special branches arising on very broad filaments | 11. *St. mamillosum* (p. 613) |
| 11. | Hormogones arising at the ends of filaments | 12. *St. informe* (p. 613) |

### 1. **Stigonema hormoides** (Kütz.) Born. et Flah.

Revision des Nostocacées hétérocystées, 68, 1887; Forti in De Toni, Sylloge Algarum, 5: 571, 1907; Frémy, Myxo. d'Afr. équat. franc., 397, fig. 325, 1929; Geitler, Kryptogamenflora, 499, fig. 302, 1932; Frémy, Cyano. cotes d'Eur., 190, pl. 63, 1933.

Pl. 134, Figs. 1–4

Filaments prostrate, densely intertwined, long, forming a thin tomentose, blackish brown thallus; filaments 7–15 μ broad, irregularly and sparesely branched, lateral branches, erect, nearly as thick as the main filament, curved; sheath thick, colorless or yellow to yellowish brown; cells subspherical, mostly

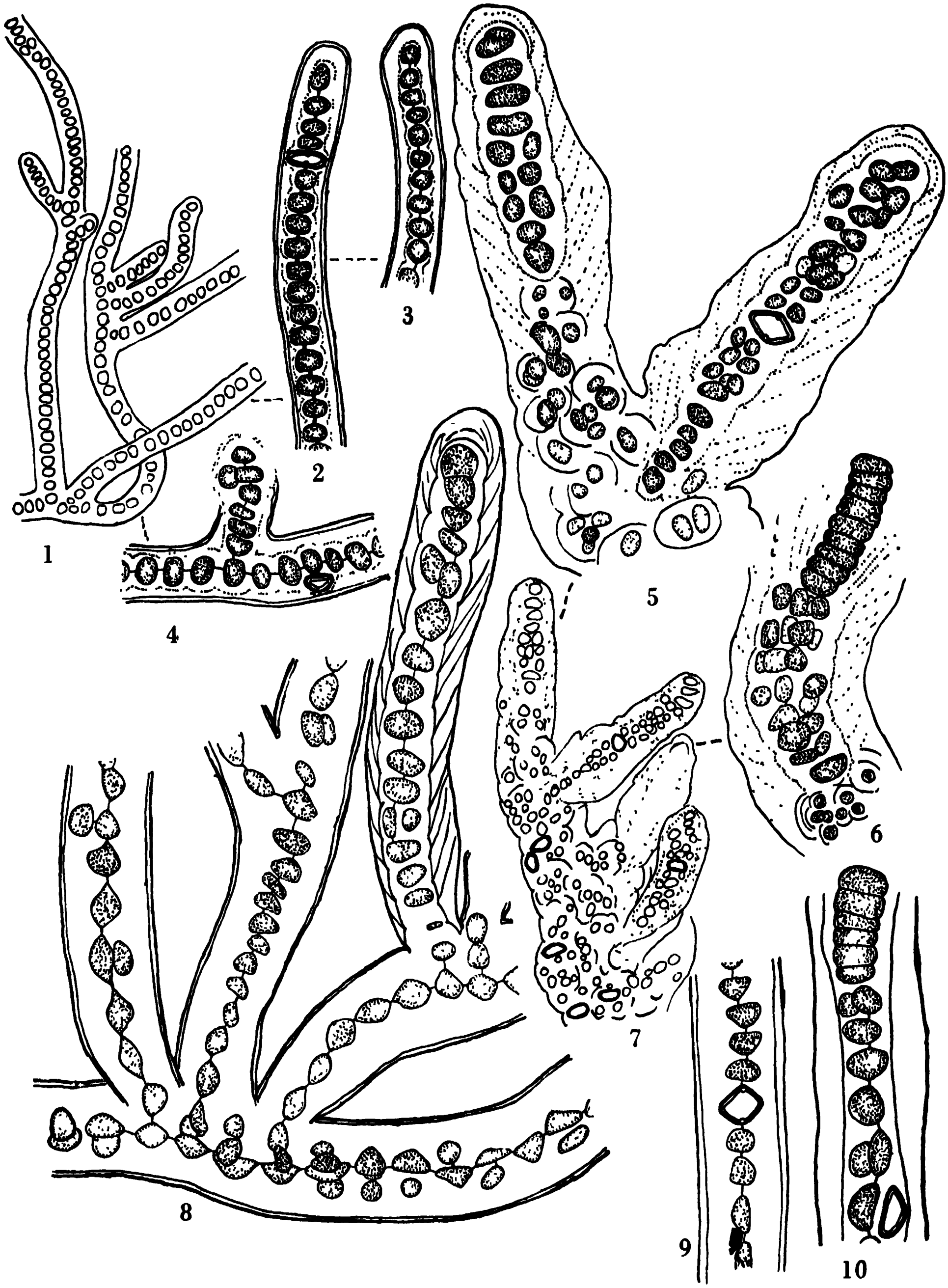

PLATE 134, Figs. 1–10.

1–4. *Stigonema hormoides* (Kütz.) Born. et Flah. (orig.); 5–7. *Stigonema mesentericum* Geitler (orig.); 8–10. *Stigonema panniforme* (Ag.) Kirchner (orig.).

single rowed, occasionally in two rows; heterocysts sparse, intercalary or lateral; Chroococcoid conidia frequently present; hormogones ( ? ).

On moist surfaces. — Panchgani, near Bombay (Schmidle, 1900b, 161) Suket and Tonglu mountains (Carter, 1926, 269), and Kodaikanal (Frémy, 1927, 46/47; 1942, 22) ( ! ).

In Frémy's specimens from Kodaikanal the filaments were 6–8 μ broad. The Kodaikanal specimens observed by the author are slightly broader (Filaments 11.8–17 (–18.3) μ broad; cells 5.2–10.5 μ broad and 3.9–9.2 μ long; heterocysts 5.2–7.9 μ broad and 2.6–3.9 μ long).

### 2. **Stigonema aerugineum** Tilden

Minnesota algae, Myxo., 245, pl. 15, fig. 14, 1910.

Pl. 119, Fig. 1

Thallus forming a brown membranous layer; filaments 25 μ in diam., rounded at the apices, rare, mixed with other algae; branches short, straight, spreading; sheath thick, homogeneous, colourless; cells 14 μ broad, 6–8 μ in length, oval or depressed globose, crowded, usually forming a single row; heterocysts 8 μ broad, somewhat spherical; cells contents bright blue-green.

On soil surface of a flat meadow, Cherrapunji, Assam (Biswas, 1934, 16).

The Assam alga appears to be somewhat different from Tilden's alga.— (Filament (25–) 28–32 μ broad, trichome (14–) 16–20 μ in diam., cells (6–8) 10–14–20 μ long.)

### 3. **Stigonema tomentosum** (Kütz.) Hieron.

Bemerkungen über einige Arten d. Gattung, *Stigonema*, Hedwigia, 34: 164, 1895; Forti, in De Toni, Sylloge Algarum, 5: 581, 1907; Geitler, Kryptogamenflora, 502, 1932.

Thallus up to 2 mm thick, blackish brown, filaments 14–28 μ broad (seldom up to 38 μ broad), prostrate, lateral branches erect, closely adpressed in erect caespitose bundles, mostly with a single row of cells, occasionally in two rows; cells 10–12 μ broad, often with a dull colored special membrane; sheath yellowish brown; hormogonia about 10 μ broad, 40–100 μ long.

Igatpuri, Bombay (Schmidle, 1900b, 161).

### 4. **Stigonema panniforme** (Ag.) Born. et Flah.

Revision des Nostocacées hétérocystées, 71, 1887; Frémy, Myxo. d'Afr. équat. franc., 403, fig. 328, 1929; Geitler, Kryptogamenflora, 503, fig. 304, 1932; Frémy, Cyano. cotes d'Eur., 190, pl. 164, 1933.

= *Stigonema panniforme* (Ag.) Kirchner, Algenflora von Schlesien, 230; Forti in De Toni, Sylloge Algarum, 5: 580, 1907.

Pl. 134, Figs. 8–10 & Pl. 138, Fig. 1

Thallus expanded, caespitose, brownish to blackish; filaments intricate, prostrate, with erect filaments 1 mm high, 24–36 μ broad ends attenuated, irregularly branched; branches erect, more or less laterally agglutinated, as broad as the main filament, hormogones bearing, 12–15 μ broad; sheath thick, lamellated, yellow to yellowish brown, outer surface rough; cells broader than long, more or less discoid, generally in a single row; heterocyst sparse, mostly intercalary; hormogones terminal about 100 μ long and 20 μ broad.

In tufts on stems of *Osbeckia buxifolia* on the summits of Hakgala rocks in exposed situations, Ceylon (West and West, 1902, 201); in the neighbourhood of Shembaganur (Frémy, 1942, 22).

Elenkin (1938 p. 476) includes *St. panniforme, St. tomentosum, Sirosiphon truncicola* Rabenh., *Sirosiphon intermedius* var. *braunii* Kütz., *Sirosiphon compactus* Rabenh., under *Stigonema ocellatum* (Dillw.) Thuret. He creates five forms to receive the various forms, f. *globosum* (Nordst.) Elenkin, f. *braunii* (Kütz.) Elenk., f. *ocellatum* (Thuret) Elenk., f. *panniforme* (Ag.) Elenk., and f. *tomentosum* (Kütz.) Elenk.

5. **Stigonema ocellatum** (Dillw.) Thuret ex Born. et Flah.

Thuret, Essai class. nostoch., Ann. Aci. nat. Bot. ser. 6, 1: 380, 1875; Bornet and Flahault, Revision des Nostocacées hétérocystées, 69, 1887; Forti in De Toni, Sylloge Algarum, 5: 528, 1907; Frémy, Myxo. d'Afr. équat. franc., 399, 1929; Geitler, Kryptogamenflora, 504, figs. 305–307, 1932.

Pl. 138, Fig. 2

Thallus cushion like, caespitose, wooly or tomentose, brownish; filaments prostrate or partly erect, about 3–8 mm high, 35–45 (–50) μ broad, irregularly branched; branches as broad as or smaller than the main filament, at the ends with hormogones; sheath thick, mostly distinctly lamellated, mostly yellow to brown, sometimes colorless in the young portions at the ends of filaments; cells in a single row or in two rows, often wider than long, 18–30 μ broad, with a colorless or brown individual envelopes; heterocysts mostly lateral, sparse; hormogones 50–65 μ long and about 15 μ broad.

Poona (Schmidle, 1900b, 161); paddyfields, Hanaratgodha in Ceylon (West and West, 1902, 201).

Lemmermann (1910, p. 231) records broader and longer hormogones (15–25 μ broad and 50–200 μ long).

Elenkin (1938, p. 476) enlarges the circumscription of this species.

6. **Stigonema mesentericum** Geitler

in Pascher's Süsswasserflora, 184, fig. 223, 1925b; Kryptogamenflora, 509, fig. 308, 1932.

Pl. 134, Figs 5–7

Filaments prostrate, dense with short protuberant branches, 25–32 μ broad, coralloid-like; sheath thick, firm, lamellated, yellow-brown; trichome

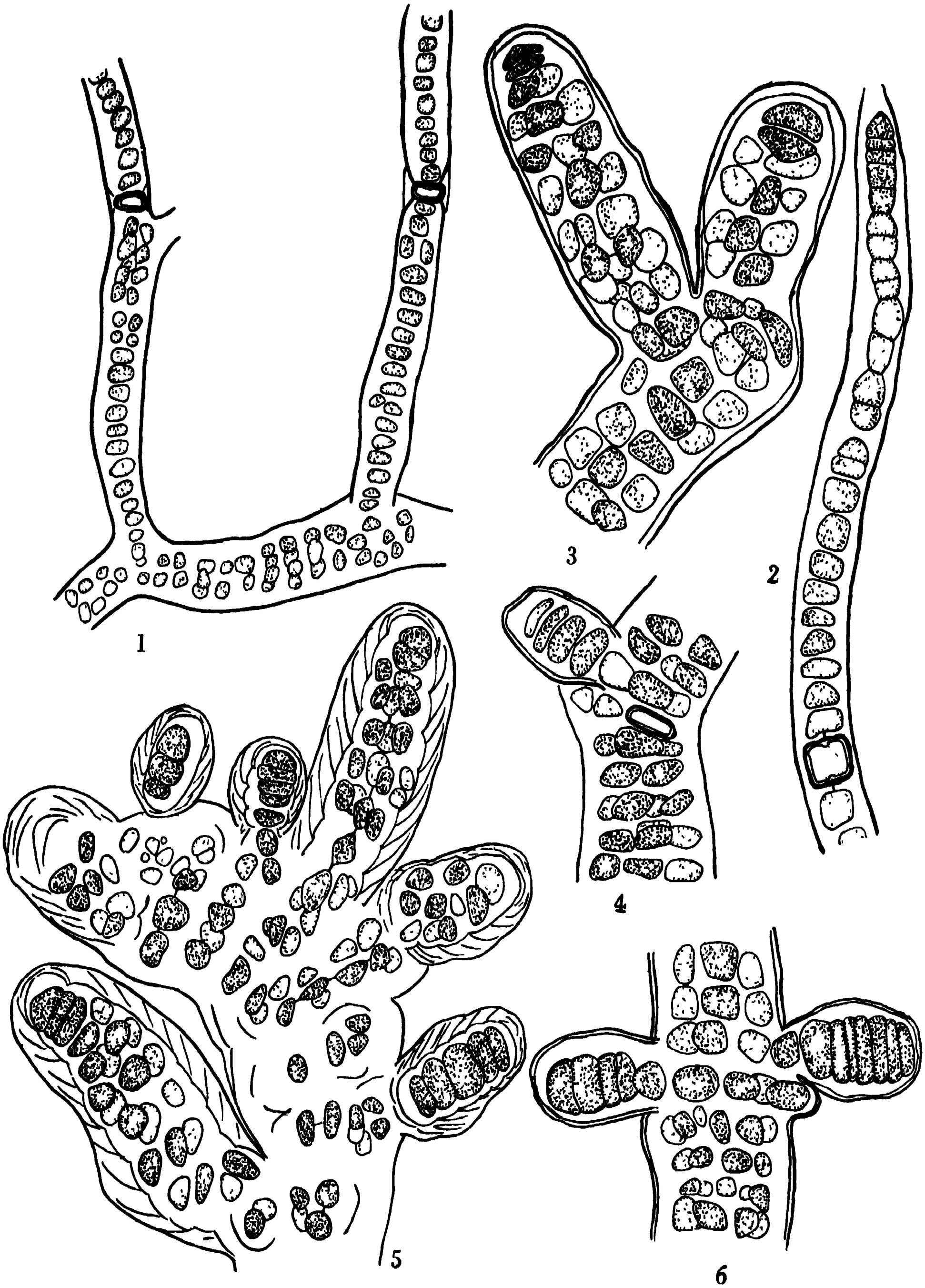

PLATE 135, Figs. 1–6.

1–2. *Stigonema dendroideum* Frémy (orig.); 3–6. *Stigonema mamillosum* (Lyngb.) Ag. (orig.).

with 2–4 or seldom with many rows of cells, cells in the older parts of the filament with a special envelope; heterocysts lateral or intercalary; hormogonia not known.

On moist rocks near Gundar falls, near Kodaikanal ( ! ).

The cells in the Kodaikanal form are 6.6–10.5 μ broad. Hormogones have also been observed in the alga and they are long, torulose with short cells which are up to ½ as long as broad, and about 10 μ broad.

### 7. **Stigonema turfaceum** (Berk.) Cooke ex Born. et Flah.

Cooke, Brit. Freshw. Algae, 273, 1884; Bornet and Flahault, Revision des Nostocacées hétérocystées, 74, 1887; Forti in De Toni, Sylloge Algarum, 5: 584, 1907; Geitler, Kryptogamenflora, 517, fig. 318, 1932.

= *Sirosiphon pulvinatus* Bréb., in Kützing, Tab. phycologicae, 2: 10, pl. 36, fig. 1, 1850–52; Species Algarum, 317, 1849.

= *Stigonema turfaceum* (Link.) Cooke,

= *Stigonema pulvinatus* (Bréb.) Borzi, 1879.

Pl. 12, Figs. 1–3, 14–17

Thallus cushion like, blackish, up to 1 mm high; filaments at the base prostrate, later growing erect, 27–30 μ (–37) μ broad, mostly richly branched; branches erect, forming hormogones at the tips, as broad as the main filament; sheath thick, lamellated, yellowish brown; trichome with two rows of cells, seldom many rowed; heterocysts lateral; hormogenes 12 μ broad, 45 μ long.

On soil Newara Elliya, Ceylon (Zanardini, 1872, 155); Bengal (Turner, 1892, 14).

### 8. **Stigonema dendroideum** Frémy

Myxo. d'Afr. équat. franc., 405, figs. 329–330, 1929; Geitler, Kryptogamenflora, 512, figs. 310 and 311, 1932.

Pl. 135, Figs. 1, 2 and Pl. 137, Figs. 3, 4

Thallus expanded, brownish black, up to 1 mm high; filaments creeping, entangled, 16–22 μ seldom up to 25 μ broad, richly branched, branches erect, when young narrower later as broad as the main filament, with many secondary branches, secondary branches gradually attenuated; sheath inside colourless, close to the trichome, not lamellated; trichome in the main filament and primary branches with one or two seldom three rows of cells, 14–20 μ broad, in the secondary branches single rowed, 8–14 μ broad; cells 8–14 (–20) μ broad; heterocysts sparse, intercalary or lateral; hormogones 10–14 μ broad and 40–60 μ long; conidia and planococci formed at the ends of filaments.

On moist rocks near Gundar falls, Kodaikanal ( ! ).

Conidia and planococci were not observed in the Kodaikanal material.

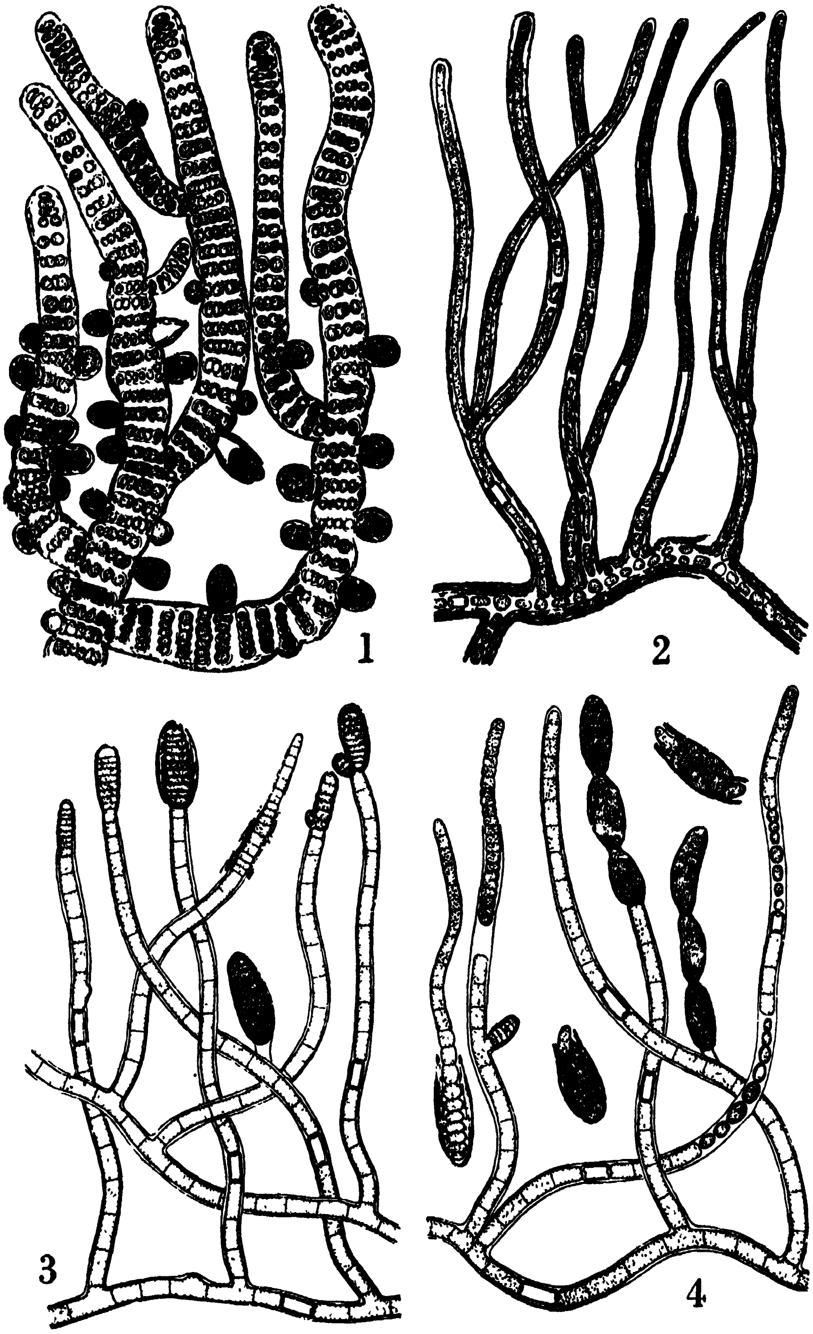

PLATE 136, Figs. 1-4.

1. *Stigonema lavardei* Frémy (after Frémy); 2. *Fischerella ambigua* (after Frémy); 3, 4. *Westiella lanosa* Frémy (after Frémy).

### 9. **Stigonema minutum** (Ag.) Hassall ex Born. et Flah.

Hass., Brit. freshw. algae, 230, pl. 67, figs 3, 4, 1845; Bornet and Flahault, Revision des Nostocacées hétérocystées, 72, 1887; Forti in De Toni, Sylloge Algarum, 5: 582, 1907; Frémy, Myxo. d'Afr. équat. franc., 408, fig. 331, 1929; Geitler Kryptogamenflora, 513, figs. 313–317, 1932; Frémy, Cyano. cotes d'Eur., 191, 1933.

= *Stigonema saxicola* Näg., in Kützing, Species Algarum, 316, 1849.

Pl. 137, Fig. 1

Thallus thin, crustaceous or cushion like, brown to black, up to 1 mm high; filaments prostrate, later erect, 15–28 μ broad, in older parts up to 35 μ broad, seldom up to 40 μ broad, flexuous, richly branched often on one side; branches partly short, partly long forming hormogones; sheath yellow to brown inner portions and individual cell envelopes mostly dull brown to nearly blackish coloured, mostly distinctly lamellated; trichome in the younger portions one or two rowed, in old parts of filaments with four or more rows of cells; heterocysts numerous intercalary or lateral; hormogones (8–) 12–15 μ broad, (18–) 21–35 (–46) μ long.

On tree trunks, moist surfaces.—N. India (Turner, 1892, 14); Bombay city, Matheran, Igatpuri and Mahabaleshwar near Bombay (Schmidle, 1900b, 161 and 180), Shembaganur near Madras (Frémy, 1942, 38); in Kamaw in Kisseraing island and in Medaw island (Ghose, 1927c, 246) and in Rangoon (Skuja, 1949, 24).

Bornet and Flahault (1887, 73) suggest the creation of varieties for the including of a number of species of *Stigonema* under *S. minutum*. The species is highly variable and the creation of a number of varieties may not be necessary. Elenkin (1938, p. 479) includes under *St. minutum, St. turfaceum, St. clavigerum, St. minutissimum* and *St. mesentericum,* species which are recognised by Bornet and Flahault (1887) and Geitler (1932) as distinct species. He reduced them to the status of forms. In this connection it is worthwhile to point out that Geitler (1925, p. 184; 1932, p. 510) suggested that *St. mesentericum* may be a very extreme growth form of *S. minutum* or other species of *Stigonema.* Pending investigations on the growth conditions and form variations in *Stigonema minutum* these species may be kept separate.

### 10. **Stigonema lavardei** Frémy

Rev. algol., Paris, 1: 45, pl. 3, 1924; Frémy, Myxo. d'Afr. équat. franc., 412, figs. 334, 335, 1929; Geitler, Kryptogamenflora, 518, fig. 319, 1932.

Pl. 136, Fig. 1

Thallus blackish green, caespitose, up to 2 mm high; filaments rigid, richly branched, at the base up to 50 μ broad; branches straight or little

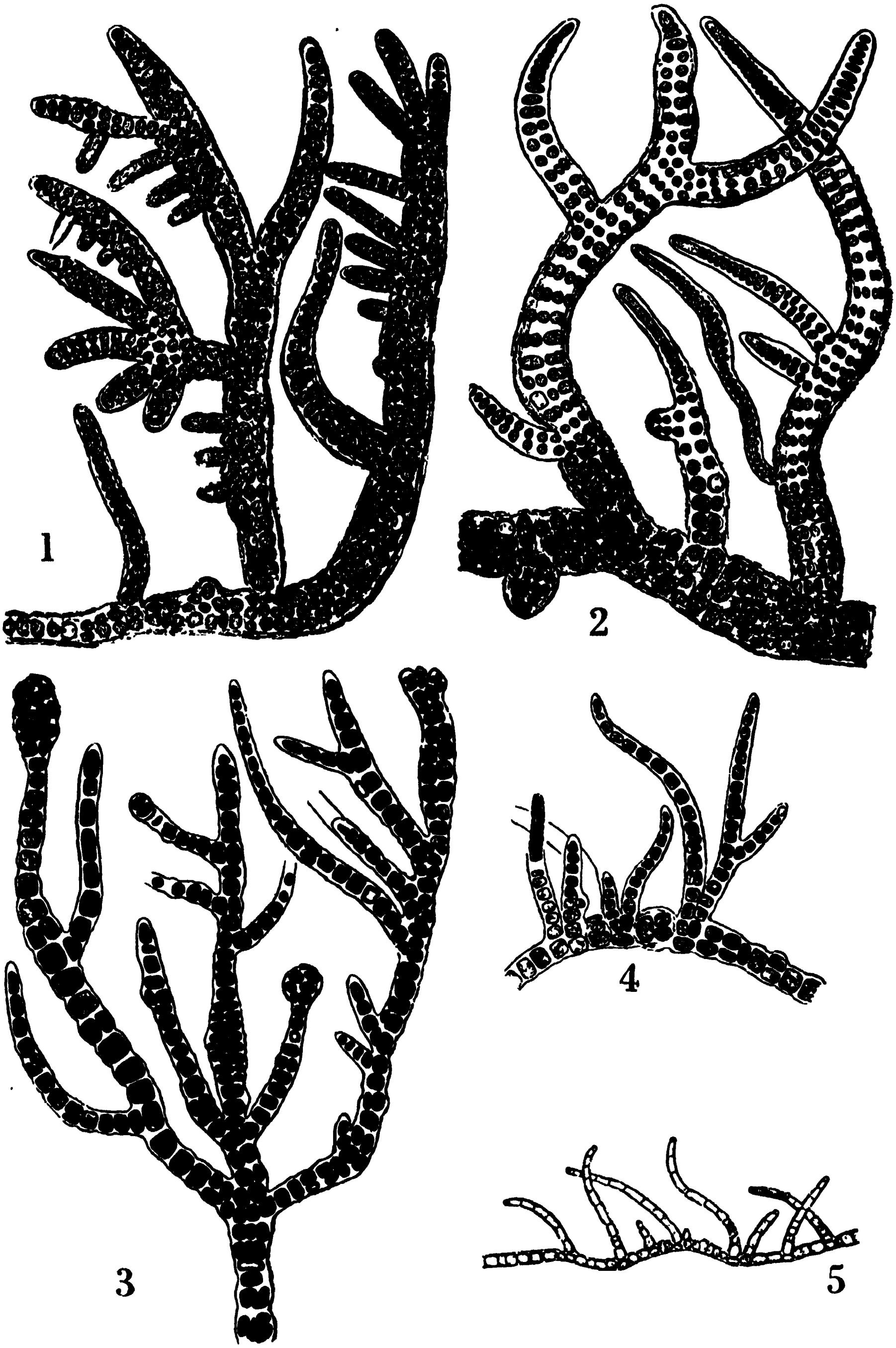

PLATE 137, Figs. 1–5.

1. *Stigonema minutum* (Ag.) Hass. (after Frémy); 2. *Stigonema informe* Kütz. (after Frémy); 3, 4. *Stigonema dendroideum* Frémy (after Frémy); 5. *Hapalosiphon welwitschii* (after Frémy).

curved, 50–55 μ broad, many small hormogones forming branches present, subspherical or clavate, up to 30 μ long; sheath thin, brownish yellow, scarcely lamellated, not torulose, coloured violet by chlor-zinc-iodide, trichomes with 4–6 rows of cells, cells mostly 10–12 μ broad; hormogones about 25 μ long, 22–24 μ broad; heterocysts not known.

Type not recorded.

### Var. **indica** Frémy

Cyanophycées de l'Inde méridionale, Blumea, suppl. 2: 38, 1942.

Cells of filaments and branches somewhat longer; heterocysts lateral, many; hormogoniferous branches less broad and somewhat longer.

On moist soil, in the environs of Shembaganur. (Frémy, *loc. cit.*).

### 11. **Stigonema mamillosum** (Lyngb.) Ag. ex Born. et Flah.

Ag., Syst. Algarum, 42, 1824; Bornet and Flahault, Revision des Nostocacées hétérocystées, 77, 1887; Forti in De Toni, Sylloge Algarum, 5: 587, 1907; Frémy, Myxo. d'Afr. équat. franc., 416, figs. 336–337, 1929; Geitler, Kryptogamenflora, 520, figs. 320–324, 1932.

Pl. 135, Figs. 3–6

Thallus cushion like, dull brown to dark blackish green; up to 12 mm high; filaments interwoven, more or less entangled, up to 65 or seldom up to 90 μ broad, richly branched at the base; branches 40–50 μ broad, or somewhat broader sometimes, with long, broadly developed lateral branches or with short mamilliform hormogoniferous branches; hormogoniferous branches short, about 24 μ broad; sheath colourless or yellowish when the form is aquatic or yellowish to dull brown; cells in the older parts regularly barrel-shaped; trichome with many rows of cells; heterocysts lateral; hormogones as a rule formed on side branches (8–) 12–15 μ broad and (18–) 40–50 μ long.

On rocks in the bed of a stream, at Tirupati Hills, Andhra Pradesh.

### 12. **Stigonema informe** Kütz ex Born. et Flah.

Kütz., Spec. Alg. 319, 1849; Tab. phycologicae, 2: 11, pl. 38, fig. 3, 1850–1852; Bornet and Flahault, Revision des Nostocacées hétérocystées 75, 1887; Forti in De Toni, Sylloge Algarum, 5: 585, 1907; Frémy, Myxo. d'Afr. équat. franc., 412, fig. 333, 1929; Geitler, Kryptogamenflora, 523, fig. 326, 1932.

Pl. 137, Fig. 2

Thallus expanded, crustaceous or caespitose, or sometimes occurring as single filaments, brownish or blackish; filaments 1–2 mm long, 40–70 μ broad,

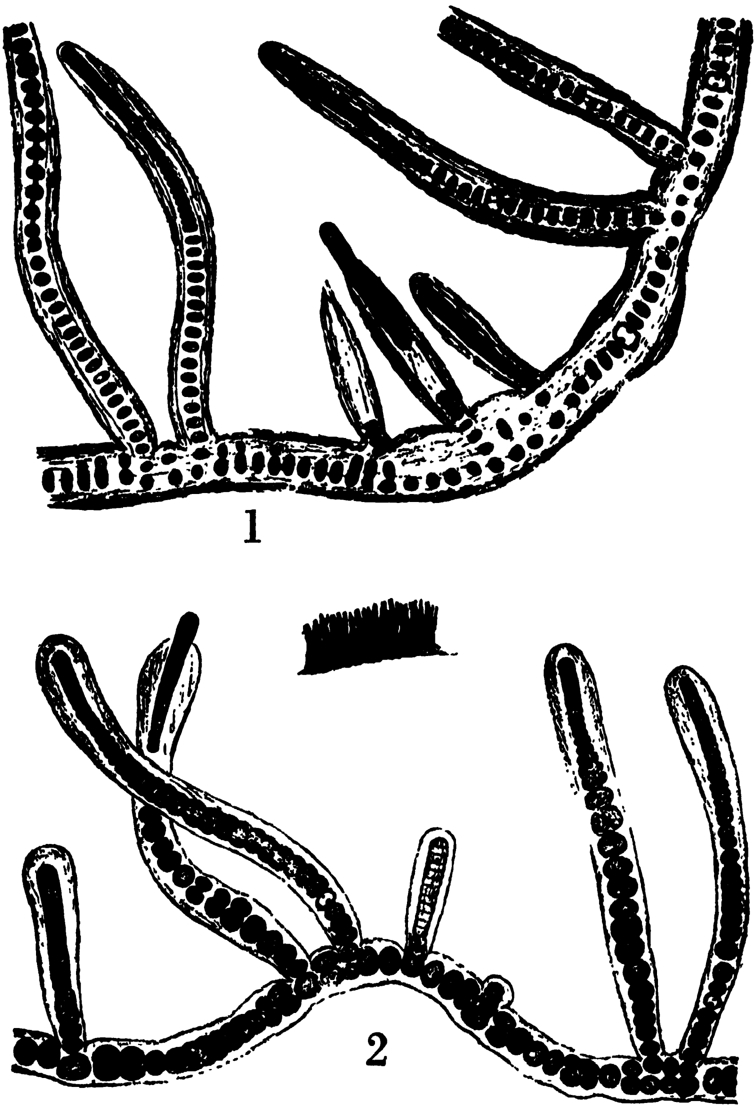

PLATE 138, Figs. 1–2.

1. *Stigonema panniforme* (Ag.) Kirchner (after Frémy); 2. *Stigonema ocellatum* (Dillw.) Thuret (after Frémy).

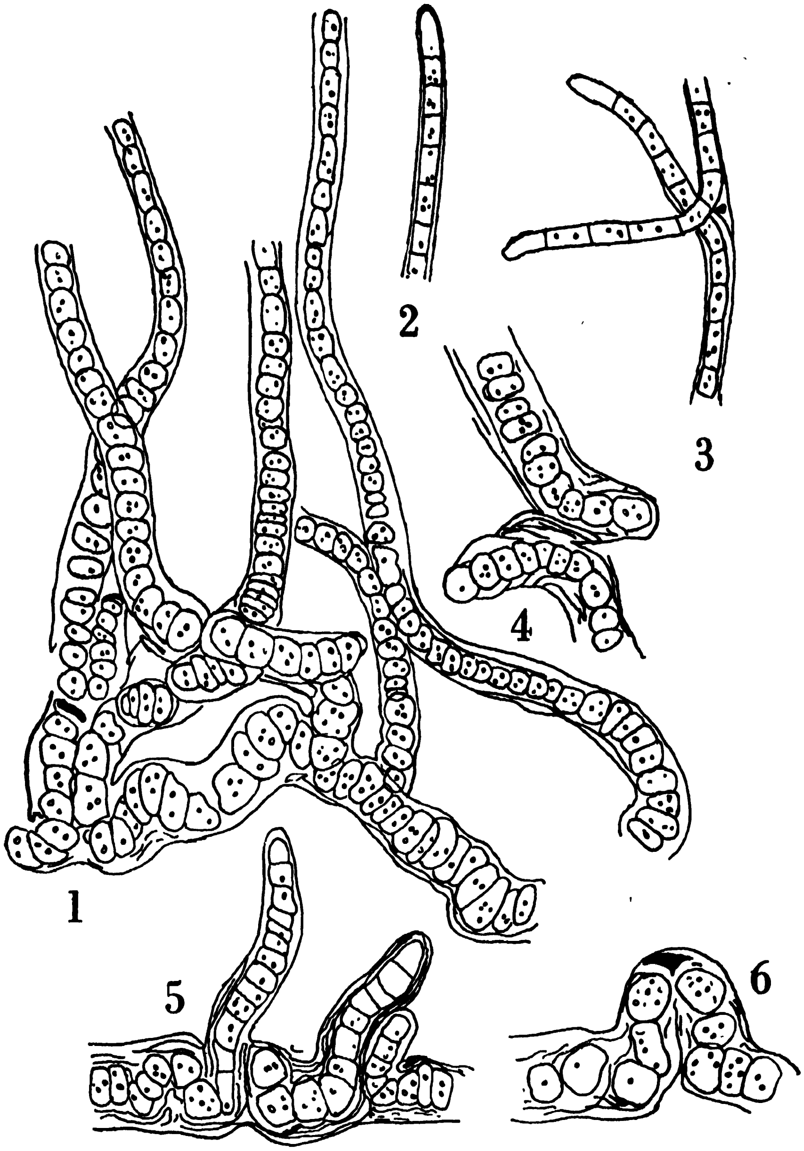

PLATE 139, Figs. 1–6.
*Seguenzea anthonyi* Gupta (after Gupta).

prostrate below and erect above, irregularly branched; branches straight or flexuous, up to 45 µ broad, with secondary branches mostly arising from the upper surface, which form hormogones; trichome with 4–6 rows of cells or seldom with many rows; cells 15–18 µ broad; heterocysts many, lateral; hormogones 18 µ broad, and 45 µ long or sometimes longer, single or in series.

Shembaganur in Madras State (Frémy, 1942, 38).

## DOUBTFUL SPECIES OF UNCERTAIN POSITION

*Hormosiphon coriaceus* Kütz. (see Martens, 1870, p. 259; Prain, 1905, p. 334).—Along the Botanic Gardens, Hooghly River, Bengal. (*Nostoc commune*).

*Leptothrix mamillosa* Menegh. (see Martens, 1871, p. 173; Prain, 1905, p. 334; Biswas, 1926, 27).—On submerged mud, Salt lakes, Calcutta.

*Hyphaeothrix investiens* Martens (see Martens, 1870, p. 11).—Between Silligoree and Titalya, in stagnant waters, forming a dense covering on plants, Bengal.

*Mastigonema granulatum* Martens. (Martens, 1870, p. 258; Prain, 1905, 334).—On stems of grasses, etc., in tanks and in slow running waters, Howrah dist., Bengal.

*Sirosiphon parasiticus* Zeller (Zeller, 1873a, 174; Zeller, 1873, p. 184; Theobald, 1883, 22).—On leaves in Choung-menah, Pegu, Burma.

*Symphyosiphon multistriatus* Zanard. (Zanardini, 1872, p. 155).—Between mosses, Pedra-talla-galla, Ceylon.

# LATIN DIAGNOSES OF NEW TAXA*

## *Microcystis elongata* sp. nov.

Coloniae elongatae, nonnumquam clathratae, usque ad 1 mm. longae, non-constrictae, mucilagine coloniarum distincta, aliquando lamellata, hyalina, refractiva; cellulae arcte sed non catervatim dispositae, dispositione haud iniformi, 3.9–5.2 μ latae, vacuolis vaporosis praesentibus.

In massa planktonica in templi cisterna ad Madras, in collectione auctoris sub numero 102.

## *Dactylococcopsis fascicularis* f. *indica* f. nov.

Cellulae usque ad 50, in acervis libere natantibus, curvatae vel arcuatae, apicibus fastigatis, 1.3–2.6 μ latae, usque ad 55 μ longae, caeruleo-virides.—Inter Algas typus lectus est in cisterna ad Kanchipuram; lectus etiam ad Anantapur, in Dist. Shimoga, in statu Mysore; lectus etiam in lacu ad Yercaud, et positus in collectione auctoris sub numero 103.

## *Chroococcidiopsis indica* sp. nov.

Cellulae solitariae, raro plures simul, sphaericae vel sub-sphaericae, 5.3–6.5 μ latae, parietibus firmis, endosporae 8–12 efformatae per divisionem successivam.

Inter alias Algas in dolio in laboratorio ad Madras, in auctoris collectione sub numero 104.

## *Arthrospira platensis* f. *granulata* f. nov.

Trichoma pallide caeruleo-viride, haud constrictum ad parietes transversos, 6.6–7.9 μ latum, paulo angustius ad apices, spiraliter curvatum, spiris ad apices angustioribus quam ad medium, spiris 19.3–35.4 μ et (16.1–) 20.5–44.9 μ inter se distantibus; cellulae discoideae, parietibus transversis saepe indistinctis, nonnumquam distinctis, granulatis.—In palude ad Coconada, in auctoris collectione sub numero 105.

## *Arthrospira massartii* var. *indica* v. nov.

Trichomata laxe spiraliter curvata, 3.9–5.2 μ lata, non constricta ad parietes transversos, apicibus saepe calyptratis, spiris 32.9–41.9 μ latis et spiris 38.6–51.5( –60 ) μ; cellulae $\frac{1}{3}-\frac{1}{4}$ latiores quam longae, parietibus transversis non granulatis.—In stagnis et orae maritimae lacunis ad Madras, in auctoris collectione sub numero 106.

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* The author is grateful to Prof. Rev. Fr. Santapau, St. Xavier's College, Bombay for kindly rendering the diagnoses into latin.

### *Spirulina laxissima* f. *major* f. nov.

Trichoma 1.3 μ latum, spiris non vicinis, ca. 6.6 μ latis.

Pudukkotah, in statu Madras, in auctoris collectione sub numero 107.

### *Oscillatoria subbrevis* f. *minor* f. nov.

Trichomata 3.9–5.2 μ lata, cellulae 3–2 μ longae.—In palude stagnante ad Saidapet, prope Madras in auctoris collectione sub numero 108.

### *Oscillatoria salina* f. *major* f. nov.

Trichoma unicum, 6.6–7.9 μ latum, non constrictum ad parietes transversos, cellulis semper brevioribus quam latis, apice curvato vel flexo, cellula apicali non hyalina, calyptra nulla.—In salinis ad Pakala, in auctoris collectione sub numero 109.

### *Plectonema thomasinianum* var. *vandalurense* v. nov.

Filamenta efformant stratum coriaceum, 14.2–25 μ latum; vagina roseo-rubra, tenuis in novellis, lamellata in vetustioribus, usque ad 3.5 μ crassa, stratificatione parallela; pseudoramuli adsunt, singuli; trichomata 7.1–17.8 μ lata; constricta ad parietes transversos, non attenuata ad apices, cellula apicali rotundata, non conica, non capitata, absque calyptra; cellulae brevissimae, usque ad 3.5 μ longae.—In humo ad Vandalur in auctoris collectione sub numero 110.

### *Mastigocladus laminosus* var. *indicus* v. nov.

Filamenta intertexta, 6.6–9.2 μ lata, ramis emergentibus ad utrumque latus, vagina sat crassa, hyalina atque non-lamellata in vetustioribus filamentis paulum difluens; trichomata non efformant capillos, torulosa vel paulum constricta; cellulae doliiformes in filamento principi, longe cylindricae in ramis, (2.7– ) 3.9–6.6 μ latae et (5.2) 9.2–14.4 μ longae; heterocysta intercalaria, quadrata vel ellipsoidea, 3.9–6.5 μ lata, 7.9–13.2 ( –22.3) μ longa, singula vel raro bina.—In saxis difluentibus ad Kodaikanal, in auctoris collectione sub numero 111.

*javanicum* (Kütz.) Born., *S. pascheri* Bharadw., and *S. guyanense* (Mont.) Born. et Flah.

Gonzalves, E. A., and Kamat, N. D., have described two new species of *Anabaena* (Hydrobiologia, 13(3): 236–238, 1959).—

1. ANABAENA ALATOSPORA Gonzalves et Kamat.

Plant-mass soft, mucilaginous. Trichomes single, usually curved, end-cells with rounded apices. Cells spherical to barrel-shaped, as long as broad or slightly shorter or longer than broad, 3.2–4.5 μ in diameter, 3.2–5.8 μ long. Heterocysts single, intercalary, cylindrical, 3.8–4.5 μ in diameter, 7–9 μ long. Akinetes single, cylindrical, 10.4–13 μ in diameter, 25.2–36 μ long, outer wall radially striated, wing-like striations, yellow-brown in colour, membrane 2.6–3.2 μ broad.

Along with other algae in a mucilaginous mass in a puddle at Devarayi, Mysore State.

2. ANABAENA MYSORENSIS Gonzalves et Kamat.

Plant-mass soft, mucilaginous, blue-green. Trichomes single, straight, rarely curved; end-cells with rounded apices. Cells cylindrical, with constrictions at the cross-walls, up to twice as long as broad, 5.8–7.5 μ in diameter, 6.4–12.3 μ long. Heterocysts single, intercalary, cylindrical, 5.2–7.3 μ in diameter, 9.6–14.8 μ long. Akinetes single, ellipsoidal, rarely oval, 12.5–19.4 μ in diameter, 35.8–51.6 μ long, formed on one side of the heterocyst only, outer wall with pointed spines, 3.2–4.5 μ long.

Attached to blades of grass in a puddle at Devarayi, Mysore State.

Gonzalves and Kamat have recently described 29 forms from Karnatak. (The Myxophyceae of the Karnatak I, J. Univ. of Bombay, 27: 22–36, 1958). — *Microcystis aeruginosa, M. flos-aquae, M. pseudofilamentosa, M. scripta, Aphanocapsa elachista, A. roeseana, A. grevillei, A. pulchra, Aphanothece castagnei, A. pallida, Gloeocapsa montana, Gloeothece goeppertiana, G. rupestris* v. *tepidariorum, G. rupestris* v. *maxima, Chroococcus tenax, Chr. schizodermaticus, Chr. minutus, Chr. spelaeus, Chr. lithophilus, Chr. helveticus, Chr. minor, Coelosphaerium kuetzingianum, Merismopedia punctata, Synechocystis pevalekii, S. aquatilis, Rhabdoderma sigmoidea* f. *minor, Entophysalis zonata* and *Stichosiphon sansibaricus* (=*Stichosiphon indica*). They also describe a new variety of *Gloeothece rupestris*, var. *major.* — Plant mass gelatinous, hyaline or yellow-brown; cells solitary or in colonies of two or three cells, ellipsoidal to cylindrical, 4.5–5.2 μ broad, 6.4–9.7 μ long, with sheath 19–25.2 μ broad and 22–35 μ long, colonies 30–45 μ broad, light blue-green. — On dripping rocks at Castle Rock.

They also report *Anabaena volzii* var. *crassa, Aulosira fertilissima* var. *tenuis, Calothrix fusca, Cylindrospermum muscicola, Cylindrospermum alatosporum, Gloeotrichia raciborskii, Gloeotrichia pisum, Hapalosiphon brasiliensis, Lyngbya ceylanica,* *L. confervoides, L. dendrobia, Microcoleus brasiliensis, M. acutissimus, Nostoc coeruleum, N. commune, N. microscopicum, N. muscorum, N. ellipsosporum, Oscillatoria schulzii, O. ornata, O. splendida, O. princeps, O. hamelii, O. geminata, O. tambi, Phormidium anomala, Phormidium cincinnatum, Phormidium subincrustatum, Scytonema ocellatum* and *Tolypothrix rupestris.*

G. S. Venkataraman (Observations on some Myxophyceae from High Altitudes, Bombay nat. Hist. Soc. 55: 318-321, 1958) reports eleven species.—*Aphanocapsa pulchra, Chamaesiphon subglobosus, C. curvatus, Spirulina nordstedtii, Spirulina laxa, Spirulina subsalsa, Oscillatoria proboscidea, O. ornata, O. quadripunctulata* v. *unigranulata, Lyngbya epiphytica* and *Scytonema ocellatum.*

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# INDEX TO THE GENERAL PART

(Latin names of plants and animals are printed in *italics*; Numerals printed in *italics* refer to the pages on which figures occur).

Acrothermae, 52
Aegagrophilous forms, 51
Aheterocysteae, 61
Akinetes, 43; structure, 43; formation, 43; germination, 45
Amoeba and blue-greens, *54*
*Amphithrix*, 51
*Anabaena*, *14*, 15, 16, 19, 21, 22, 23, 29, 43, 45, 47, 50, 51, 57, 58, 61; *A. affinis*, *24*; *A. ambigua*, 15; *A. azollae*, *42*; *A. catenula*, 47; *A. catenula* v. *affinis*, 47; *A. circinalis*, *7*, 47; *A. circinalis* v. *cyrtospora*, 47; *A. cycadeae*, *28*, 30; *A. cylindrica*, 15, 26, *42*; *A. echinospora*, *24*; *A. fertilissima*, 15; *A. flos-aquae*, 47; *A. gelatinicola*, 15; *A. humicola*, 15; *A. kuetzingiana*, *42*; *A. levanderi*, 47; *A. macrospora*, 47, 58; *A. macrospora* v. *robusta*, 47; *A. naviculoides*, 15; *A. spiroides*, 47; *A. torulosa*, 49; *A. utermöhli*, 47; *A. variabilis*, 15
Anabaenin, 13, 17
*Anabaeniolum*, 57
*Anabaenopsis*, 15, 27; *A. arnoldii*, *24*; *A. elenkinii*, 47
*Anabaenothrix*, 22
*Anacystis nidulans* (= *Aphanothece nidulans*), 16
Angiosperms and blue-green algae, 57
Antarctic blue-green algae, 53
Anhomocysteae, 62
*Anthoceros*, 57
Aphanin, 9
Aphanicin, 9
Aphanizophyll, 9
*Aphanizomenon*, 16, 19, 51, 58; *A. flos-aquae*, 9, 16, 47; *A. gracile* (?), 58; *A. recurvum*, 47
Aphanizoxanthophyll, 9
*Aphanocapsa*, 51, 60; *A. distans*, 57; *A. littoralis*, 49; *A. marina*, 49; *A. pulchra*, 49; *A. sescianensis*, *14*
*Aphanothece*, 12, 43, 51, 57; *A. bullosa* v. *major*, *38*; *A. caldariorum*, *38*; *A. castagnei*, 50; *A. halophytica*, 49, 50; *A. microscopica*, 19; *A. nidulans*, 16; *A. prasina*, *7*
Apical growth, 6
Arabinose, 13
*Archaeothrix*, 58; *A. problematica*, 58
Archéthallus, *46*, 65
Arginine, 8
Arrhenius Law of temperature influence on irreversible chemical reactions, 21
*Arthrospira*, 4, 19, 50; *A. platensis*, 47
*Aulosira*, 67; *A. fertilissima*, 15; *A. implexa* v. *crassa*, 39; *A. pseudoramosa*, 37
*Azolla*, 57

Bacteria and blue-green algae, 53
Basal heterocysts, 25
*Blasia*, 57
Bottom-living forms, 16
*Brachynema*, 50
*Brachytrichia*, 29, 33, 35, 39, 61, 68; *B. balani*, *24*, 27, *34*
Branching, 32–37; true branching, 32; dichotomous branching, 33, *34*; false branching, 4, *34*, 37; lateral branching, 33, *34*; reverse V-shaped branching, 33, *34*
Bryophytes and blue-greens, 57

Calcium carbonate deposition and blue-green algae, 50
Calorhodin, 9
*Calothrix*, 4, 16, 21, 29, 50, 51, 53, 58, 61; *C. brevissima*, 15; *C. confervicola*, *36*; *C. parietina*, 15; *C. pulvinata*, 15; *C. scopulorum*, 25; *C. weberi*, *28*, 30, 31
*Camasia*, 60

*Camptylonema,* 37, 41; *C. indicum, 36*
Capsosiraceae, 33
Carotenes, 9; β-carotene, 9; 4-keto-β-carotene, 9
Catalase, 16
Cell, 6–15
Cell-division, 13
Cell sheath, 13
Cell-wall, 13; pores in, 15
Cellulose, 13, 23
Central body, 6
Centroplasm, 6, 11–13
*Chalarodora azurea,* 53, *56*
*Chaetoceros contortum, 56*
*Chamaesiphon,* 4, 43, 51, 60; *C. curvatus, 38*; *C. fuscus,* 4, *40,* 43
Chamaesiphonaceae, 60
Chamaesiphonales ( = Dermocarpales), 43, 48, 61
Chemotaxis, 21
Chitin, 13
*Chlorochromatium,* 53
*Chlorogloea,* 43, 67; *C. fritschii,* 67
Chlorophyll, 9; chlorophyll *a*, 9; chlorophyll *b*, 9
Chlorosis, 9
Chondriome, 13
*Chondrogloea,* 51
Chromatin, 12
Chromatin reticulum, 12
Chromatoplasm, 6–11, 16; lamellae, 9
Chromonemata, 12
Chroococcaceae, 60
Chroococcales, 43, 45, 46
*Chroococcus, 7,* 15, 17, 22, 55, 58; *C. quaternarius,* 57; *C. turgidus, 5, 7,* 8, 15, 19, 49
*Chroomonas gemma,* 55
Classification, 60
*Clastidium,* 60
*Clavicularia,* 57
Coccogoneae, 60
Coccoid forms, 3, 60
Coccospores ( = endospores), *46,* 65
Coccothalus, *46*
Cold water forms, 53
*Collema,* 55
*Collenia,* 60
Colorless forms, 57
*Colteronema,* 33
Complementary chromatic adaptation, 10
*Coelosphaerium,* 4, 16, 19, 22; *C. dubium,* 47; *C. kuetzingianum,* 47; *C. naegelianum,* 47
*Conochilus unicornis,* 55
*Cryptella cyanophora,* 55
Crytozoan, 60
Crystalloids, 15
Crystals of gypsum, 15
Cyanellae, 53
*Cyanodictyon,* 4, 53; *C. reticulatum, 5*
*Cyanophora paradoxa,* 55
Cyanophyceae, 68
Cyanophyta, 3, 68
Cyanophycin granules, 8, 15, 17, 26
Cyanoplasts, 8
*Cyanoptyche gloeocystis,* 53, *54, 56*
*Cyanostylon,* 4; *C. cylindrocellulare, 5*
*Cycas,* 57
*Cylindrospermum,* 19, 23, 37, 43, 58; *C. alatosporum, 24*; *C. gorakhpurense,* 15; *C. licheniforme,* 15, *42*; *C. majus,* 15; *C. muscicola* v. *kashmiriensis, 24*; *C. sphaerica,* 15
Cytoplasmic connection, 15
Cytotoxin, 47

*Dactylococcopsis,* 15, 55; *D. pectinatellophila,* 55; *D. raphidioides, 5*
*Dalmetella,* 50
*Dermocarpa,* 41; *D. clavata, 40*; *D. hemisphaerica, 40,* 41; *D. incrassata, 40*; *D. prasina, 40,* 41; *D. suffulta,* 41; *D. xenococcoides,* 41
Dermocarpales, 41
*Dermocarpella,* 41; *D. hemisphaerica, 40*
*Desmonema,* 23
*Desmosiphon,* 43
Desoxyribonucleic acid (DNA), 12
Diastase, 16
*Dichothrix,* 51, 55, 57
Dichotomous branching, 33, *34*
Diosmotic changes, 20
*Diplonema,* 23
Discs of intercellular substances, 39
Dolomites, 50
*Dunaliella salina,* 48
*Dzensia salina,* 49

Echinenone, 9
Ectocyanoses, 55
Ectoplasts, 8
Endocyanoses, 55
Endolithic forms, 50
*Endonema,* 41; *E. moniliforme, 38*
Endoplasts, 8
Endophytic forms, 53
Endospores, *30,* 41–43, 65
Endotoxin, 48
Entophysalidaceae, 4
Enzymes, 16, 31
*Ephebe,* 57
Epibiontic forms, 55
Epilithic forms, 50
*Epilithia,* 50
Epiplasts, 8
*Eucapsis,* 3; *E. alpina, 5,* 19
Euryhaline, 48
Euthermae, 52
Euthermophilae, 52
Exospores, 43

False branching, 4, *34,* 37
Fat, 8, 15
Fermentation products, 17
Ferns and blue-green algae, 57
Feulgen reaction, 12
Filament, 4
Filamentous forms, 4; origin of the filamentous condition, 65, 66, 67
*Fischerella, 36,* 41
*Fischerellopsis,* 37, 39
Fish mortality, 47
Flagellates and blue-greens, 55
Flavicin, 9
Floatation, 17
Fluorescence, 10
*Floscularia mutabilis,* 55
Fossil blue-greens, 58
Fungal parasites, 58
Fuscochlorin, 25
Fuscorhodin, 25

Gaidukov phenomenon, 10
Galactose, 13
Gas-vacuoles, 16–17; function of, 16
*Geosiphon pyriformis,* 53
Germination of heterocysts, *28,* 29
Germination of spores (akinetes), *42,* 45
Giant cells, 49
*Girvanella,* 58; *G. minuta,* 58
*Glaucocystis nostochinearum,* 53, *54*
*Glaucocystis cingulata,* 53
*Gloeocapsa,* 22, 43, 51, 53, 55, 60; *G. alpicola* 7; *G. crepidinum,* 43; *G. dimidiata,* 16; *G. membranina,* 16
Gloeocapsin, 25
*Gloeocapsites,* 60
*Gloeocapsamorpha,* 58
*Gloeochaete wittrockiana,* 53, *54*
*Gloeothece linearis, 5,* 15, 19; *G. rhodochlamys, 24*
*Gloeothecites,* 60
*Gloeotrichia,* 4, 12, 16, 23, 29; formation of spores, 43; germination of spores, *42*; *G. echinulata,* 47; *G. natans, 42,* 47; *G. pisum, 5*; *G. raciborskii, 28,* 30, 58
*Gloioconis subtetrapedia,* 60
Glucose, 13
Glycogen, 15
Glycolytic enzymes, 16
Glycoproteins, 15
*Gomphosphaeria,* 4, 41; *G. aponina* v. *cordiformis, 5*
Gonidia, 30
Grana, 8
*Gunnera,* 57
Gymnosperms and blue-greens, 57

Hairs, 6; classification and, 61
Halophilic forms, 48, 49
Halotolerant forms, 48, 49
*Handeliella,* 37, 41
*Hapalosiphon,* 4, 23, 26, 33, 35, 37, 51
*Hassallia,* 37
Hemicellulose, 23
*Herpyzonema,* 41; *H. intermedia, 40*
Heterocysteae, 61
Heterocystous forms, 4
Heterocysts, 4, 25–32; occurrence, 25; pores of, 25, 26; nutrients and, 29; vacuolization, 29; rejuvenation, 30; spore formation and, 32; structure, 26; formation, 27; gas vacuoles and, 31;

germination, 29; function, 30; classification and, 61
Heterotrichous forms, 4
Heterotrophic nutrition
Hliarothermae, 52
*Holopedia,* 3, 19
Homocysteae, 61
Homocystous forms, 4
Homocystineae, 61
*Homoeothrix,* 61
*Hormathonema,* 50
Hormocysts, 39
Hormogonales, 39
Hormogoneae, 60
Hormogones, 4, 19, 21, 37–39; formation, 39; germination, 39; movements, 39, 46
Hormospores, 39, *46*, 65
Hot springs algae, 51
*Hydrocoleum,* 51
*Hyella,* 4, 50
Hyellaceae, 62, 64
*Hyellococcus,* 51
Hyperhaline, 48
Hyperthermae, 52
*Hyphaeothrix,* 51
Hypohaline, 48
Hypothermae, 52
Hypothermophilae, 52

*Inactis,* 51
Incipient nucleus, 12
Indian salt lakes, 50
Indian fossil blue-greens, 60
Inner investment, 13, 15
Intercalary heterocysts, 25
Intercalary meristematic region, 6
Intus-susception, 23
Invertase, 16
Iron deposition by blue-green algae, 51
*Isocystis,* 20

*Johannesbaptistia,* 4, 67

*Kyrtuthrix,* 50

Lateral branching, 33
Lateral heterocysts, 25
*Leptopogon,* 41
Lichens and blue-greens, 55
Light and akinete germination, 45 and movements, 20
Lime boring algae, 50
Lime deposition, 50
Lipase, 16
*Lithomyxa,* 51
*Lithonema,* 50
*Loefgrenia,* 64
Loefgreniaceae, 64
*Loriella osteophila, 36*
Lutein, 9
*Lyngbya,* 4, 12, 16, 20, 21, 23, 51, 53, 57, 67; *L. aestuarii,* 16, 49; *L. hieronymusii,* 47; *L. limnetica,* 47; *L. margaretheana, 5*; *L. ochracea,* 51; *L. versicolor,* 11

Mannose, 13
Marine forms, 48
Mastigocladaceae, 61
Mastigocladopsidaceae, 61
Mastigocladaceous branching, 33, 34
*Mastigocladus, 34,* 35, 51, 68; *M. laminosus,* 15, 27, *34,* 51, 52
*Mastigocoleus,* 33, 39, 61; *M. testarum, 24,* 50
*Merismopedia,* 3; *M. glauca,* 49; *M. punctata,* 5, 19
Mesothermophilae, 52
Metachromatin granules, 8, 12, 13
*Microchaete,* 67
*Microcoleus,* 19, 51; *M. chthonoplastes,* 48, 49; *M. tenerrimus,* 49
*Microcystis,* 4, 16, 19, 43, 47, 57, 58; *M. aeruginosa,* 15, 47, *56*; *M. elabens,* 47; *M. flos-aquae,* 47; *M. ichthyoblabe,* 47; *M. ochracea,* 47; *M. orissica,* 55; *M. prasina,* 47; *M. scripta,* 47; *M. toxica,* 47; *M. viridis,* 47
Mitochondria, 6
Molluscs and blue-green algae, 50
Monostichous forms, 65
Movements, 19–21; rate of, 20; causation of, 19
Mucilage, 21–25; secretion of, 22; structure, 22; mucilaginous envelopes, 21; mucilaginous sheaths, 21, 23
Mutatochrome, 9

Myoxanthin, 9
Myxoxanthin, 9
Myxoxanthophyll, 9
Myxorhodin, 9

Nannocytes, 43
Necridia, 46
Nematogenae, 60
*Newlandia*, 60
Nitrogen chlorosis, 11
Nitrogen fixation, 15
*Nodularia*, 23, 67; *N. spumigena*, 47
Non-filamentous forms, 3
*Nostoc*, 12, 15, 16, 21, 22, 23, 29, 45, 53, 55, 58; *N. carneum*, 47; *N. commune*, *24*, *28*, *30*; *N. ellipsosporum*, *42*; *N. insulare*, 31; *N. linckia*, *14*, *28*, 47; *N. microscopicum*, 30; *N. muscorum*, 15; *N. paludosum*, 15; *N. punctiforme*, 15, *42*; *N. symbioticum*, 53
Nostocaceae, 41, 43, 60
Nostocales, 37, 45, 61
Nostochinées, 60
Nostochopsidaceae, 33, 61
*Nostochopsis lobatus*, *24*, *36*
*Nostocites*, 58; *N. vesiculosa*, 58
Nuclear membrane, 11
Nucleoli-like bodies, 12
Nutrition

*Oicomonas*, 53, 55
Oolites, 58
Open nucleus, 12
*Oscillatoria*, 4, 6, *7*, 12, 13, *14*, 15, 16, *18*, 19, 20, 21, 22, 37, 49, 51, 57, 58; *O. aerugineus*, 47; *O. agardhii*, 47; *O. angusta*, 21, 57; *O. borneti*, *5*, *7*, *14*; *O. brevis*, 49; *O. brevis* v. *variabilis*, 49; *O. carotinosa*, 10; *O. formosa*, 21; *O. fröhlischii*, *18*; *O. limosa*, 9, *18*, 23; *O. kuetzingiana* v. *crassa*, 49; *O. planctonica*, 47; *O. princeps*, 9; *O. prolifica*, 12, 47; *O. pseudoacutissima*, 10; *O. redeki*, 47; *O. rubescens*, 9; *O. sancta*, 10, *18*; *O. splendida*, 12, 21; *O. tambi*, 49; *O. tenuis*, *7*; *O. tenuis* v. *subfusca*, 58
Oscillatoriaceae, 41, 45, 60
Oscillatoriales, 61
Oscillaxanthin, 9
*Oscillaspira*, 57
Osmotic pressure and rate of movement, 21

Palmelloid green algae and blue-greens, 53
*Paracapsa siderophila*, 51
Parasitic forms, 57
Pathology of blue-green algae, 58
*Paulinella chromatophora*, *54*, 55
Pectic substances in sheath, 23
*Pectinatella burmanica*, 55
Pedicellate heterocysts, 25
*Peliaina cyanea*, 55, *56*
Pentosans, 23
Perforating forms, 50
*Petalonema*, 51; *P. alatum*, 18; *P. crustaceum* ( = *Scytonema crustaceum*), 50
*Phlyctidium anabaenae*, 58
*Phormidium*, 16, 20, 23, *46*, 50, 51, 53; *P. ambiguum*, 49; *P. ambiguum* v. *major*, *14*; *P. autumnale*, *7*; *P. ectocarpi*, 10; *P. favosum*, *7*; *P. foveolarum*, 16, 49; *P. fragile*, 10, 49; *P. incrustatum*, 51; *P. laminosum*, 16; *P. lividum*, 16; *P. mucicola*, 55, *56*; *P. retzii*, *7*; *P. uncinatum*, *44*; *P. tenue*, 10, 16, 49, 51
Photosynthesis, 15
Phycocyanin, 10; *C*-phycocyanin, 10; *P*-phycocyanin, 10
Phycoerythrin, 10; *C*-phycoerythrin, 10
Phycoxanthin, 9
Phylogeny, 60
Pigmentation, 8–11
Pit-connections, 15
*Placynthium*, 57
Planktonic forms, 45
Planococci, 43
Plasmolysis, 6
*Plectonema*, 4, 51, 61, 67; *P. nostocorum*, 16; *P. notatum*, 16; *P. terebrans*, 50
*Pleurocapsa*, 4, 50
Pleurocapsales, *46*, 48
*Podocapsa*, 50
Polar granules, 26
Polystichous forms, 65
Polyzoa and blue-green algae, 55
Pores in cell wall, 15
Proteolytic enzymes, 16

Protoplasmic connections, 15, 26, 27
Protothallus, *46*, 65
*Pseudanabaena,* 12, 61; *P. biceps,* 57
Pseudofilamentous condition, 4
Pseudohormocysts, 41, 43
Pseudohormogonia, 39; formation, 39; germination, 41
Psilonemeae, 60
Pulvinulariaceae, 33
Purine, 13
Pyramidine, 13

*Radaisia,* 50
Range of vegetative construction, 3–6
*Raphidiopsis,* 68
Refractive crystals, 15
Rejuvenation of heterocysts, 30
Relict hypothesis, 52
Reproduction, 37
Resting spores (Akinetes), 43
Reverse ' V '-shaped branching, 33, *34*
*Rhabdoderma,* 53
*Rhizophidium globator,* 58; *R. subangulatum,* 58
*Rhizosolenia,* 53, *56*
*Richelia,* 68; *R. intracellularis,* 53, *56*
*Rivularia,* 4, 6, 30, 49, 51, 53, 55, 61; *R. bioselettiana,* 50; *R. bullata,* 15; *R. dura,* 50; *R. haematites,* 50; *R. polyotis,* 5
Rivulariaceae, 43, 60
Rotifers and blue-green algae, 55

Salinity, 48
Salt manufacture and blue-green algae, 48
Saltwater forms, 48
Sapropelic forms, 57
Schizophycose, 23
*Schizothrix,* 50, 51; *S. fasciculata,* 51; *S. lacustris,* 51; *S. lateritia,* 51
*Scopulonema,* 50
*Scytonema,* 4, 6, 22, 23, 37, 41, 51, 55, 60, 61; *S. arcangelii, 24*; *S. crispum,* 9; *S. geitleri, 36*
Scytonemaceae, 60
Scytonemataceae, 39, 43
Scytonemine, 25
Sea urchins and blue-green algae, 55
Secretion theory of movements, 19
Sheath, 21; lamellation, 18, 23; pigmentation, 25
*Simonsiella,* 57
*Siphononema,* 41, 63, 65; *S. polonicum,* 5, *40*
Sirosiphonaceae, 60
*Solentia,* 50
*Spalaeopogon,* 41
*Spirillum,* 53, 55
*Spirulina,* 4, 12, 19; *S. gomontiana,* 49; *S. major,* 49; *S. subsalsa,* 49; *S. thompsoniana* 49
Spores (akinetes), 43
Sporocysts (sporangia), *46*
*Stauromatonema*
Stenohaline, 48
*Stichosiphon,* 43; *S. sansibaricus* (*S. indicus*), *40*
*Stigonema,* 6, 15, 23, 39, 51, 55, 63; *S. mamillosum, 5, 7,* 12; *S. minutum, 36*; *S. ocellatum, 14*; *S. turfaceum, 44*
Stigonemaceae, 60
Stigonemataceae, 15, 61
Stigonematales, 33, 37, 39, 43, *46*, 61
Sulphur, 15
Symbiotic forms, 53
*Symploca,* 20, 58; *S. jurassica,* 58, *59,* 60
Syncyanoses, 53
*Synechococcus,* 19, 53; *S. aerugineus,* 22; *S. cedrorum, 7,* 8, 15; *S. elongatus* v. *amphigranulatus,* 51; *S. major, 5*
*Synechocystis,* 60
Synoptic arrangement of families and orders, 68

Temperature and movements, 21
Terminal heterocysts, 25
Thermal, 52
Thermal algae, 51
Thermal algae of India, 52
Thermophile forms, 52
*Tildenia,* 67
*Tolypothrix,* 4, 12, *14,* 16, 29, 37, 51, 58; *T. distorta* v. *penicillata, 24*; *T. elenkinii,* 30, *44*; *T. lanata, 14*; *T. penicillata* v. *tenuis,* 30, *44*; *T. tenuis,* 15
Toxicity, 47
Travertine
Trehalose, 15

*Trichodesmium*, 19, 47; *T. erythraeum*, 11, 47; *T. thiebautii*, 47
Trichome, 4
Trichomothallus, *46*
Trichophoreae, 60
*Trifolium alexandrinum*, 57
True branching, 4, 32
*Tryponema*, 50
*Tubiella*, 65, 67
Tubiellaceae, 65

Vacuoles, 8
Vacuome, 13
Vegetative propagation, 37
Volutin, 8, 13

Water-blooms, 11, 17, 47
*Westiella*, 4, 41; *W. intricata*, *36*
*Westiellopsis*, 41, 43
*Wollea*, 22

Xanthophyll, 9

*Zamia*, 57
Zeaxanthin, 9
*Zonotrichites*, 60

# INDEX TO GENERA, SPECIES, ETC.

Index to the species and genera of the systematic part (Synonyms and pages on which figures occur are printed in *italics*).

*Agmenellum* Bréb., 80
— *thermale* (Kütz.) Dr. and D., 135
*Amorphonostoc* Elenk., 350
— *paludosum* (Kütz.) Elenk., 375
— *punctiforme* (Kütz.) Elenk., ( — *Nostoc punctiforme*), 374
Anabaena Bory, 349, 391
— alatospora Gonzalves and Kamat, 620
— *allahabadii* Mitra, 418
— anomala Fritsch, 398, *399*
— ambigua Rao, C. B., 370, 400, *407*
— aphanizomenoides Forti, *394*, 405
— — v. *ellipsospora* Rao, C. B., 406, *416*
— ballygunglii Banerji, 409, 412
— beckii De Toni, 405
— *bullosa* Kütz., 418, 581
— *circinalis* (Kütz.) Hansg., 414
— circinalis Rabneh., *412*, 414
— — v. crassa Ghose, *412*
— — v. *macrosperma* (Wittr.) Forti, *412*
— constricta Szafer, *394*, 419
— doliolum Bharadw., 410, 416
— fertilissima Rao, C. B., 398, *402*
— flos-acquae (Lyngb.) Bréb., 414
— — v. *circinalis* Kirchn., 414
— fuellebornii Schmidle, *394*, 401, *404*
— gelatinicola Ghose, 398, *407*
— *gelatinosa* Fritsch, 396
— *hansgirgi* Schmidle, 418
— hassallii (Kütz.) Wittr., 414
— *inaequalis* (Kütz.) B. and F., 413
— *indica* Beck, 405
— *indica* Zeller, 411
— iyengarii Bharadw., 406, *416*
— —*forma* Singh, R. N., 406
— —*forma* Rao, C. S., 406
— — v. attenuata Rao, C. B., *407*, 408
— — v. tenuis Rao, C. B., *407*, 408
— — v. unispora Singh, R. N., 408, 416
— khannae Skuja, 396, *404*
— *kashiensis* Bharadw., 413

Anabaena—(*contd.*)
— *kuetzingiana* De Toni, 413
— laxa (Rabenh.) A. Br., 413
— *moniliforme* ( ? ), 418
*mollis* Kütz., 255
mysorensis Gonzalves and Kamat, 620
naviculoides Fritsch, *397*, 410
— *nordstedtii* Turner, 418
*oblonga* De Wilde., 413
orientalis Dixit, 405, *412*
— — v. ellipsospora (Rao, C. B.) comb. n., 406
— oryzae Fritsch, 396, *397*
— oscillarioides Bory, 391, *394*, 417
*forma* Parukutty, 417
— — v. *angustus* Bharadw., *416*, 418
randhawae Venkataraman, 619
sphaerica B. and F., 393
— — v. attenuata Bharadw., *394*, 395
— — v. *indica* (Beck) Biswas, 405
— — v. tenuis West, G. S., 393, *394*
— spiroides Kleb., 395
— v. contracta Kleb., 396
— v. *crassa* Lemm., *394*
— v. *minor* Uterm., 415
— *stagnalis* Kütz., 363
*subtilissima* Kütz., 418
thermalis Vouk v. *indica* Fritsch, 398
torulosa (Carm.) Lagerh., 394, 415
— —*forma* Fritsch, *399*, 417
*unispora* Gardner, 403
— — v. *crassa* Rao, C. B., 403, *416*
— utermöhlii (Uterm.) Geitler, *402*, 415
— variabilis Kütz., *394*, 410
—*forma* Rao, C. B., 411
— v. kashiensis (Bharadw.) Fritsch *412*, 413
— v. ellipsospora Fritsch, *397*, 411
vaginicola Fritsch and Rich, 370, *399*, 401
— — f. fertilissima Prasad, *399*, 401

Anabaena—(*contd.*)
— volzii Lemm., 403, *412*
— — v. *crassa* (Rao) Bourelly, 403
— — v. crassa (Rao) Fritsch, 403, *416*, 620
Anabaenopsis (Wolosz.) Miller, 349, 353
— arnoldii Aptekarj, 356
— — v. indica Ramanathan, *355*, 356, 357
— circularis (West, G. S.) Wolosz. and Miller, 354
— — v. javanica Wolosz., 356, *357*
— elenkinii Miller, 353
— raciborskii Wolosz., *357*, 358, 420
— tanganyikae (West, G. S.) Wolosz. and Miller, 354, *357*
*Anabaenothrix* Ghose and Randhawa, 350
— *cylindrica* Ghose and Randh., 370, *407*
— *epiphytica* Ghose and Randh., 370, *407*
— *vaginicola* (Fritsch and Rich) Ghose and Randhawa, 370, 401
*Anacystis* Menegh., 80, 99
— *cyanea* (Kütz.) Dr. and D., 85, 87, 91, 93, 95, 99
— *dimidiata* (Kütz.) Dr. and D., 99
— *incerta* (Lemm.) Dr. and D., 96
— *marginata* Menegh., 87
— *marina* (Hansg.) Dr. and D., 136
— *montana* (Lightf.) Dr. and D., 96
— — f. *minor* (Wille) Dr. and D., 96
— — f. *montana* Dr. and D., 99
— *thermalis* (Menegh.) Dr. & D., 99
— — f. *major* (Lagerh.) Dr. and D., 99
Aphanizomenon Morren, 359
— flos-aquae (L.) Ralfs, 359, *520*
— incurvum Morren, 359
Aphanocapsa Näg., 79, 130
— *albida* Zeller, 130
— banaresensis Bharadw., *104*, 133
— biformis A. Br., *100*, 134
— brunnea Näg., 134
— crassa Ghose, *104*, 136
— delicatissima West, W. and G. S., 133
— elachista West, W. and G. S., *100*, 132, 620
— — v. conferta West, W. and G. S., 104, 133
— — v. irregularis Boye-Pet., 133
Aphanocapsa—(*contd.*)
— grevillei (Hass.) Rabenh., *100*, 134, 619, 620
— koordersi Strom, *110*, 132
— littoralis Hansg., *100*, 131, 619
— — v. macrococca Hansg., 131
— montana Cramer, *92*, 135
— muscicola (Menegh.) Wille, *100*, 135
— parietina Näg., 130
— pulchra (Kütz.) Rabenh., *100*, 132, 620, 621
— *rivularis* (Carm.) Rabenh., *100*, 130
— roeseana De Bary, 131, 620
— *serpentina* ( ? ), 130
— testacea (A. Br.) Näg., 130
— thermalis (Kütz.) Brügg., 135
— *virescens* (Hass.) Rabenh., *100*, 130
Aphanothece Näg., 79,136
— bullosa (Menegh.) Rabenh., *104*, 136, 142
— caldariorum Richter, P., 138
— castagnei (Bréb.) Rabenh., *100*, 136, 140, 619, 620
— clathrata West, W. and G. S., *104*, 136, 137
— conferta Richter, 140
— microscopica Näg., *104*, 136, 142
— naegelii Wartm., *104*, 136, 141
— nidulans Richter, *104*, 136, 138
— pallida (Kütz.) Rabenh., *104*, 136, 140, 620
— — f. minor Dixit, 141
— *prasina* A. Br., *100*
— saxicola Näg., *104*, 136, 138
— — *forma*, Rao, C. B., 138
— stagnina (Spreng.) A. Br., *100*, 136, 137
Aplococcus Roze, 80
Arthrospira Stizenb., 187
— gomontiana Setchell, 192
— — v. crassa (Gupta) comb. nov. 192
— jenneri Stizenb., 187, *188*, 192
— khannae Dr. and Strickl., *188*, 189
— massartii Kuff., *188*, 191
— — v. indica var. n., *188*, 191, 617
— platensis (Nordst.) Gom., *188*, 190
— — f. granulata f.n., *188*, 190, 617
— — v. tenuis (Rao) comb. n., *188*, 190
— — v. non-constricta (Banerji) comb. n., 191, *194*

Arthrospira—(*contd.*)
— spirulinoides Ghose, *188*, 189
— — f. tenuis (Singh) comb. n., 189
— tenuis Bruhl and Biswas, 191
Aulosira Kirchner, 350, 424
— aenigmatica Frémy, *427*, 428
— bombayensis Gonzalves, 426, *429*
— fertilissima Ghose, *425*, 431
— — v. tenuis Rao, C. B., *425*, 431, 620
— fritschii Bharadw., *425*, 432
— implexa B. and F., 430
— — v. crassa Dixit, *425*, 430
— laxa Kirchner, 424, 428
— prolifica Bharadw., 426, *427*
— pseudoramosa Bharadw., *427*, 430
Bacularia Borzi, 79, 80
Beckia Elenk., 79
Brachytrichia Zanard., 577
— *balani* (Lloyd) B. and F., 580
— quoyi (Ag.) B. and F., *578*, *579*, 580, 619
Cagniardia Trev., 80
Calothrix Ag., 522
— *anomala* Mitra, 544
— bharadwajae De Toni, 526, *536*
— braunii B. and F., 535, *541*, 619
— *brébissonii* Kütz., 438
— brevissima West, G. S., *532*, 533, *541*
— — v. moniliforme Ghose, 533, *536*
— breviarticulata West, W. and G. S., *532*, 537
— castellii (Massal.) B. and F., 529, *541*
— — v. somastipurense Rao, C. S., 531, *539*
— *catenata* Mitra, 544
— clavata West, G. S., *541*, 542
— clavatoides Ghose, 531, *539*
— confervicola (Roth) Ag. 522
— contarenii (Zanard.) B. and F., 524, *534*
— crustacea Thuret, 524, *534*, 619
— dolichomeres Skuja, *530*, 540
— elenkinii Koss., 531, *541*
— —*forma* Rao, C. B., 531
— epiphytica West, W. and G. S., 543
— *fritschii* Bharadw., 526
— fusca (Kütz.) B. and F., *520*, 527, 620
— —*forma* Rao, C. B., 529, *539*
— — v. minor Wille, 529
— — v. crassa Rao, C. S., 529, *539*
— gardneri J. De Toni, 535
— geitonos Skuja, *530*, 537
Calothrix—(*contd.*)
— ghosei Bharadw., 526, *536*
— gloeocola Skuja, *530*, 542
— *gypsophila* (Kütz.) Thur., 545
— *hansgirgi* Schmidle, 521
— indica Montagne, 544
— javanica De Wilde., *518*, 524, *547*
— *juliana* (Menegh.) B. and F., 519
— *linearis* Gardner, 535, *547*
— —*forma* Rao, C. B., 535
— marchica Lemm., *541*, 543
— — v. crassa Rao, C. B., *539*, 543
— — v. intermedia Rao, C. B., *539*, 544
— membranacea Schmidle, *518*, 542
— — v. *purpurea* Mitra, 544
— parietina (Näg.) Thuret, *528*, 538, *547*
— pulvinata Ag., 619
— *ramosa* Bharadw., 544
— scopulorum (W. and M.) Ag., 524, *534*
— scytonemicola Tilden, *536*, 537
— —*forma* Bharadw., *536*, 537
— stellaris B. and F., 527, 528
— *tenuissima* A. Br., 447
— thermalis (Schmidle) Hansg., 533, *536*, *541*
— viguieri Frémy, *520*, 538
— —*forma* Rao, C. B., 538
— weberi Schmidle, 540
— wembaerensis Hieron. and Schmidle, *520*, 525, 532
Camptylonema Schmidle, 596
— indicum Schmidle, *597*, 598
— *lahorense* Ghose, 446
Camptylonemopsis Desikachary, 442
— iyengarii Desikachary, *445*, 446
— lahorensis (Ghose) Desika., 442, *445*, 446
— minor Desik., *443*, 444
— pulneyensis Desik., *443*, 444
Catella Alv., 79
Chamaesiphon A. Br. and Grun., 167
— clavatus Setchell and Gardner, 175
— confervicola A. Br., 167
— curvatus Nordst., 168, *170*, 621
— — v. turneri Forti, 168, 169
— *filamentosa* Ghose, 176
— fuscus (Rostaf.) Hansg., 168, *170*
— rostafinskii (Rostaf.) Hansg., *164*, 168, 171
— *sansibaricus* Hieron., 176

Chamaesiphon—(*contd.*)
— sideriphilus Starmach, 169, *170*
— — v. glabra Rao, C. B., 169, *170*
— subglobosus (Rostaf.) Lemm., 621
— *willei* Gardner, 176
Chlorogloea Wille, 162
— fritschii Mitra, *161*, 163
— microcystoides Geitler, *90*, 163
Chroococcidiopsis Geitler, 80, 166
— indica sp. n, *161*, 167, 617
Chroococcus Näg., 79, 80, 98
— cohaerens (Bréb.) Näg., 99, 111, *129*
— dispersus (Keissler) Lemm., 106
— — v. minor Smith, 107
— giganteus West, W., 99, 101, *129*
— gomontii Nygaard, 99, 105
— granulosus Zeller, 99, 111
— hansgirgi Schmidle, 99, 105
— helveticus Näg., 620
— indicus Zeller, 99, 109
— — v. epiphyticus Ghose, 109, *129*
— limneticus Lemm., 99, 107, *129*
— — v. subsalsus Lemm., 107
— lithophilus Erceg., 620
— macrococcus (Kütz.) Rabenh., 99, 101, *139*
— minimus (Keissl.) Lemm., 99, 106
— — v. crassus Rao, C. B., 99, 106, *129*
— minor (Kütz.) Näg., 99, 105, *122*, 620
— minutus (Kütz.) Näg., 99, 103, *122*, 619, 620
— montanus Hansg., 99, 108
— —*forma* Rao, C. B., 108, *129*
— — v. hyalinus Rao, C. B., 99, 108, *129*
— — v. *minimus* Keissler, 106
— multicoloratus Wood, 99, 109
— pallidus Näg., 99, 108, *129*
— —*forma* Rao, C. B., 109
— —*forma* Dixit, 109
— *rufescens* (Bréb.) Näg., 98
— schizodermaticus West, W., 99, 103, *129*, 620
— spelaeus Erceg., 620
— tenax (Kirchn.) Hieron., 99, 103, *129*, 620
— turgidus (Kütz.) Näg., 98, 99, 101, *129*
— — v. fuscescens (Kütz.) Forti, 99, 102
— — v. maximus Nygaard, 99, 102, *122*, *129*
— — v. solitarius Ghose, 102, *129*
Chroococcus—(*contd.*)
— varius A. Br., 99, 107, *122*
— westii (West, W.) Boye-Pet., 99, 103
— — v. *terrestris* Mitra, 103
Chroococcus (Näg.) Elenkin, 79
— subg. *Chlorogloea* (Wille) Elenkin, 79
— subg. *Eucapsis* (Clements and Shantz) Elenkin, 79
— subg. *Euchroococcus* Elenkin, 79
— subg. *Hydrococcus* (Kütz.) Elenkin, 79
Chroostipes Pascher, 79
*Chthonoblastus burmanicus* Zeller, 346
— *kurzii* Zeller, 340
— *lyngbyei* Kütz., 343
— *salinus* Kütz., 343
*Clathrocystis* Henfr. 80
— aeruginosa (Kütz.) Henfr., 93
— *elongata* (West, W. and G. S.) Forti, 83
— *holsatica* Lemm., 96
— *insignis* Beck, 98
— *robusta* Clark, 82, 85
*Coccochloris* Spreng., 79
— *aeruginosa* (Näg.) Dr. and D., 85
— *elabens* (Bréb.) Dr. and D., 97, 136
— *peniocystis* (Kütz.) Dr. and D., 136
— *stagnina* Spreng., 99, 136
Coccopedia Troitzk., 79, 80
*Coelocystis* Näg., 80
Coelomoron Buell, 80
Coelosphaeriopsis Lemm., 79, 80
Coelosphaerium Näg., 79, 80, 146
— confertum West, W. and G. S., 148
— dubium Grun., 147
— kuetzingianum Näg., 146, 148, *149*, 620
— naegelianum Unger, 146, 147, *149*
— pallidum Lemm., 146
— roseum Snow, 146
Crinalium Crow, 246
— endophytium Crow, 246
— magnum Fritsch and John, 247, *274*
Cyanarcus Pascher, 79
Cyanocloster Kuff., 80
Cyanocystis Borzi, 80
Cyanodictyon Geitler, 79
*Cyanothrix* Gardner, 163
— cavanillesii Gonz., 165
*Cyanothrix* Schmidle, 163
Cylindrospermum Kütz., 359
— alatosporum Fritsch, *361*, 362, 620

Cylindrospermum—(*contd.*)
— bengalense Biswas, 370
— *circinalis* Kutz., 414
— circinalis Rabenh., 414
— doryphorum Bruhl and Biswas, 358, *365*, 368
— gorakhpurense Singh, R. N., 363, *402*
— *hassallii* Kütz., 414
— humicola Kutz., 369
— indentatum West, G. S., 364
— — f. major Rao, C. S., *365*, 366
— indicum Rao, C. B., *361*, 369
— licheniforme (Bory) Kutz., *365*, 366
— *macrospermum* Kütz., 363
— majus Kutz., 360, *425*
— michailovskaense Elenkin, *365*, 368
— muscicola Kütz., *365*, 366, 620
— — *forma* Singh, R. N., 367
— — v. longispora Dixit, *361*, 367
— — v. kashmiriensis Bharadw., *361*, 367
— — *forma* Singh, V. P., 368
— sphaerica Prasad, *361*, 363
— *spirale* Kütz., 366
— stagnale (Kutz.) B. and F., 360, 363, *365*
— — f. sporolimbata Frémy, *361*, 364
— — f. variabilis Prasad, *361*, 364
— tropicum West, G. S. and W., 362
Dactylococcopsis Hansg., 79, 157
— fascicularis Lemm., *151*, 158
— — f. indica f. n., *151*, 158, 617
— pectinatellophila West, W., *151*, 158
— raphidioides Hansg., *151*, 158
— — *forma* Rao, C. B., 158
Dasygloea Thwaites, 250
— amorpha Thwaites, 250, *283*
Dermocarpa Crouan, 80, 171
— *clavata* Geitler, 175
— clavata (Setchell and Gardner) Geitler, *164*, 172, 175
— flahaultii Sauvageau, *170*, 172, 174
— hemisphaerica Setch. and Gardn., *170*, 172, 173, 619
— leibleiniae (Reinsch) Born. and Thuret, *170*, 172, 173
— — v. pelagica Wille, *170*, 172, 173
— olivacea (Reinsch) Tilden, *170*, 172, 174
— — v. gigantea Rao, C. B., *170*, 172, 174
— parva (Conrad) Geitler, 172, 175
— prasina (Reinsch) Bornet and Thuret, 172
Dermocarpa—(*contd.*)
— sphaerica Setch. and Gardn., 172, 174
— — *forma* Rao, C. S., 174
— versicolor (Borzi) Geitler, 170, 172, 175
— violacea Crouan, 171
*Dermocarpa* Bornet and Thuret, 172
Dermocarpella Lemm., 172
— pedicellata Feldmann, J. and G., 172
Dichothrix Zanard., 544
— baueriana (Grun.) B. and F., *534*, 546
— compacta B. and F., *520*, 545, 546
— fusca Fritsch, *528*, 545, 546
— gypsophila (Kütz.) B. and F., *520*, 545
— orsiniana (Kütz.) B. and F., *520*, 545
— penicillata Zanard., 545
*Diplocystis* J. Ag., 84
*Diplocystis* Trevisan, 80
Dzensia Woronich., 79, 80
*Endospora* Gardner, 80
Entophysalis Kutz., 80, 160
— *conferta* (Kutz.) Dr. and D., 172
— *deusta* (Menegh.) Dr. and D.,
— granulosa Kutz., *90*, *150*, 160, 619
— *lemaniae* (Ag.) Dr. and D., f. *lemaniae* Dr. and D., 168, 172
— *rivularis* (Kütz.) Dr. and D.,
— — f. *papillosa* (Kutz.) Dr. and D., 168
— — f. *rivularis* Dr. and D., 99, 172
— zonata Gardner, 620
Eucapsis Clements and Shantz, 80, 157
— minuta Fritsch, 157
*Exococcus* Näg., 80
*Fischera tenuis* Martens, 602
Fischerella (Born. and Flah.) Gom., 599
— ambigua (Nag.) Gom., 601, *610*
— *anomala* Bharadw., 602
— epiphytica Ghose, *589*, 601
— *moniliformis* Frémy, 603
— muscicola (Thuret) Gom., 601
— — v. *indica* Mitra, 601, 602
— tenuis (Martens) Forti, 602
Fischerellopsis Fritsch, 603
— moniliforme (Frémy) Fritsch, 603
Fortiea J. De Toni, 515
— bossei (Frémy) comb. n., *429*, *496*, 516
— caucasica (Elenk.) De Toni, 515
— incerta Skuja, 512, 516
*Frémyella* J. De Toni, 350
— *aequalis* Frémy, 513

*Frémyella*—(contd.)
— *bossei* Frémy, 516
— *elongata* Frémy, 513
— *grisea* (Thuret) J. De Toni, 510
— — v. *brevis* (Bharadw.) De Toni, J., 510
— *tenera* (Thuret) J. De Toni, 514
— — v. *tenuis* (Bharadw.) De Toni, J., 514
— *uberrima* (Carter) J. De Toni, 511
— — f. *minor* (Carter) J. De Toni, 511
— *violacea* (Frémy) J. De Toni, 511
Gloeocapsa Kütz., 80, 111
— aeruginosa (Carm.) Kütz., 115
— alpina Näg., 112
— atrata (Turp.) Kütz., 111, 116, *122*
— calcarea Tilden, 115, *122*
— comglomerata Kütz., 123
— compacta Kütz., 112, 121, *122*
— coracina Kütz., 121, *122*
— crepidinum Thuret, 113, 117, *139*
— decorticans (A. Br.) Richter, 114, *122*
— dermochroa Näg., 112, 118
— fusco-lutea (Näg.) Kütz., 118
— gelatinosa Kütz., 114, *139*
— granosa (Berk.) Kütz., 113, *122*, 123
— —*forma* Gonzalves, 123
— kuetzingiana Näg., *110*, 118, *122*
— *kurziana* Martens, 124
— livida (Carm.) Kütz., 116, *139*
— luteo-fusca Martens, 119, *122*
— magma (Bréb.) Kütz., 112, 120, *122*
— montana Kütz., 113, *122*, 123, 619, 620
— — f. *typica* Hollerb., 111
— nigrescens Näg., 112, 117, *122*
— pleurocapsoides Nck., 118, *122*
— polydermatica Kütz., 113, 114, *126*
— punctata Näg., 110, 112, 115
— quaternata (Bréb.) Kütz., *92*, 113, 120
— ralfsiana Kütz., 112
— rupestris Kütz., 112, 117
— — f. pallida Martens, 117
— sanguinea (Ag.) Kütz., 111, 112, 121, *139*
— stegophila (Itzigs.) Rabenh., 119, *126*
— —*forma* Rao, C. S., 119
— — v. crassa Rao, C. B., 119, *126*
— violacea (Corda) Rabenh., 123
*Gloeocapsa* (Kütz.) Elenkin, 79
— subg. *Chondrocystis* (Lemm.) Elenkin, 79
— subg. *Entophysalis* (Kütz.) Elenkin, 79
— subg. *Eugloeocapsa* Elenkin, 79
*Gloeocap*[illegible](contd.)
— subg. *Gloeothece* (Näg.) Elenkin, 79
— subg. *Placoma* (Schousb.) Elenkin, 79
— subg. *Rhabdoderma* (Schmid. and Lauterb.) Elenkin, 79
Gloeothece Näg., [illegible]9, 124
— *distans* Stizb., 124, 128
— fusco-lutea Näg., 125, *126*
— goeppertiana (Hilse) Forti, 620
— linearis Näg., 124
— membranacea (Rabenh.) Born., 124, 128
— palea (Kütz.) Rabenh., 127
— rhodochlamys Skuja, 125, *126*
— rupestris (Lyngb.) Born., 124, 126, 127
— — v. major Gonz. and Kamat, 620
— — v. maxima West, W., 127, 620
— — v. tepidariorum (A. Br.) Hansg., 620
— samoensis Wille, *110*, 128
— — v. major Wille, *110*, 128
— vibrio Carter, N., 619
Gloeotrichia Ag., 553
— atra (Roth) Biswas, 565
— echinulata (J. E. Smith) Richter, *550*, 556
— — f. brevispora West, W. and G. S., 556
— — v. berhampurense Rao, C. B., 558, *559*
— ghosei Singh, R. N., *559*, 561
— indica Schmidle, 536, 560
— intermedia (Lemm.) Geitler, *550*, 560
— — v. kanwaensis Rao, C. B., *559*, 560
— kurziana Zeller, 562
— longicauda Schmidle, *557*, 558
— natans Rabenh., *520*, *559*, 561
— pilgeri Schmidle, *550*, 558, *559*
— pisum Thuret, *550*, 553, 555, 620
— — v. lens (Menegh.) Hansg., 556
— raciborskii Wolosz., *559*, 562, 620
— — v. bombayense Dixit, *557*, 563
— — v. conica Dixit, *557*, 563
— — v. kashiense Rao, C. B., *557*, 563
— — v. longispora Rao, C. S., *559*, 564
— — v. salsettense Dixit, *557*, 564
Gomphosphaeria Kütz., 79, 148
— aponina Kütz., 148, *149*, 150
— — v. *muralis* Biswas, 150
— lacustris Chodat, 99, 146, *149*, 150
— rosea (Snow) Lemm., 146
*Gomphosphaeria* (Kütz.) Elenkin, 79
— subg. *Coelosphaerium* (Näg.) Elenkin, 79

*Gomphosphaeria*—(contd.)
— subg. *Eugomphosphaeria* Elenkin, 79
*Gonidium* Ehrenb., 80
Hapalosiphon Näg.,
— baronii West, W. and G. S., *566,* 591
— *braunii* Näg., 585, 592
— brasiliensis Borge, 620
— delicatulus West, W. and G. S., *582,* 586, 591
— flagelliformis (Schmidle) Forti, *566,* 590
— fontinalis (Ag.) Born., 585, *589,* 592
— — v. fischeroides Hansg., 592
— *fontinalis* (Ag.) Born. and Flah. em. Elenkin, 592
— — f. *fischeroides* (West, W. and G. S.) Elenkin, 592
— — f. *hibernicus* (West, W. and G. S.) Elenkin, 592
— — f. *intricatus* (West, W. and G. S.) Elenkin, 592
— hansgirgi (Schmidle) Forti, 590
— hibernicus West, W. and G. S., 593
— intricatus West, W. and G. S., 586, *587,* 591
— *laminosus* Hansg., 581
— luteolus West, W. and G. S., *589,* 593
— *pumillus* Kirchn., 585, 592
stuhlmannii Hieron., 587, 593
welwitschii West, W. and G. S., 588, *612*
— — *forma* Rao, C. B., 588, *589*
— — v. vaginatus Ghose, 588
*Hassallia* Berk.,
— *bouteillei* (Bréb. and Desm.) B. and F., 499
— *byssoidea* Berk., 502
— *ceylonica* Schmidle, 500
— *rechingeri* Wille, 503
*Heterohormogonium* Copeland, 163
Holopedia Lagerh., 79, 80
*Holopedium* (Lagerh.) Elenk., 79
— subg. *Coccopedium* (Troitz.) Elenk., 79
— subg. *Euholopedium* Forti, 79
— subg. *Microcrocis* (Richter) Forti, 79
Homoeothrix (Thuret) Kirchn., 517
— africana West, G. S., 519
— hansgirgi (Schmidle) Lemm., *518,* 521, *536*
— juliana (Menegh.) Kirchn., 517, 519, *520*
— — f. tenuis Singh, R. N., 519
*Hormactis* Zanard., 577
*Hormosiphon cylindraceus* Zanard., 330
*Hormospora pellucida* Dickie, 165
Hormothamnion Grun., 350, 432
— enteromorphoides Grun., *352,* 433
— solutum Born. and Grun., 433
Hydrococcus Kütz., 80, 180
— rivularis Kütz., *153,* 180
Hydrocoleum Kütz., 346
— cantharidosum (Mont.) Gom., *274,* 347
— heterotrichum Kütz., *274,* 348
— *kurzii* Martens, 340
— lenormandi Martens, 349
— lyngbyaceum Kütz., *274,* 347
— meneghinianum Kütz., 348
— striatum Zeller, 349
— violaceum Martens, 348
— viridula Zeller, 349
Hydrocoryne Schwabe, 446
— spongiosa Schwabe, 447
Hyella Born. and Flah., 183
— caespitosa B. and F., 183, *184*
*Hyphaeothrix* Kütz.,
— *aeruginea* Rabenh., 334
— — var. *subtorulosa* Zeller, 334
— *calcicola* Ag. f. *muralis* Rabenh., 328
— *confervae* Kütz., 334
— *investiens* Martens, 616
— *lateritia* Kutz., 326
— — f. *lyngbyacea* Schmidle, 326
— *porphyromelana* Bruhl and Biswas, 326
*subtilissima* Rabenh., 259
— *subundulata* Martens, 332
— *tenax* Martens, 334
— *tenax* Wolle, 334
— *viridula* Zeller, 334
Isocystis Borzi, 349
Iyengariella Desik., 598
— tirupatiensis Desik., 599, *600*
Johannesbaptistia De Toni, J., 80, 163
— *gardneri* Frémy, 165
— pellucida (Dickie) Taylor and Dr., *164,* 165
— *primaria* (Gardner) De Toni, 165
— *Willei* (Gardner) De Toni, 165
Katagnymene Lemm., 247
— pelagica Lemm., 247, *283*
— spiralis Lemm., 247, *283*
Krkia Pevalek, 80

*Kyrtuthrix* Erceg., 577
*Leibleinia* Endl.,
— *corallinae* Kutz., 221
— *juliana* Kutz., 519
— *martensiana* v. *distincta* Nordst., 286
*Lemmermannia* Elenkin, 80, 146
Lemmermannia Chodat, 79
Lemmermanniella Geitler, 80, 146
*Leptobasis* Elenkin, 515
Leptochaete Borzi, 521
— hansgirgi Schmidle, 521
*Leptothrix muralis* Kütz., 328
— *ochracea* Kütz., 301
— *subtilissima* Kütz., 259
Lyngbya Ag., 278
— aerugineo-coerulea (Kutz.) Gom., *288*, 315
— — v. *terrestris* Mitra, 317
— aestuarii Liebm., *304*, 305
— — f. spectabilis Gom., 307
— — f. symplocoides Gom., 307
— — v. arbustiva Bruhl and Biswas, *300*, 307
— — v. constricta Ghose, *300*, 307
— — v. tenuis Dixit, 308
— allorgei Frémy, *312*, 313, 619
— arboricola Bruhl and Biswas, 248, 305, *316*
— aureo-fulva West, W. and G. S., 302
— baculum Gom., 285, *292*, *304*
— — *forma* Iyengar and Desik., 285
— bipunctata Lemm., *288*, 290
— birgei Smith, G. M., *295*, 296
— — *forma* Gupta, 296
— borgerti Lemm., 293, *306*
— calcifera Bruhl and Biswas, 301, *316*
— ceylanica Wille, 299, *312*, 619, 620
— — *forma* Rao, C. B., 299
— — *forma* Rao, C. B., 299
— — v. *constricta* Frémy, 299, *312*
— chaetomorphae Iyengar and Desik., 281, *292*
— cinerescens Kütz., 315
— *cincinnata* Kutz., 453
— circumcreta West, G. S., 291
— — v. gelatinicola Ghose, 291, *300*
— confervoides Ag., 278, *292*, *304*, 314, 621
— connectens Bruhl and Biswas, *300*, 308
— contorta Lemm., *288*, 290, *295*
Lyngbya—(*contd.*)
— corbierei Frémy, 320
— corticicola Bruhl and Biswas, 303, *316*
— — *forma* Rao, C. B., 303
— *crispa* Ag., 321
— — v. *violacea* Kütz., 321
— cryptovaginata Schkorbatow, *295*, 297
— dendrobia Bruhl and Biswas, 248, *295*, 302, *316*, 621
— — *forma* Rao, C. B., 303
— — f. lurida Bruhl and Biswas, 302
— — v. skujaii nom. n., 303
— digueti Gom., 306, 310
— — *forma* Rao, C. B., 311
— — *forma* Banerji, 311
— distincta (Nordst.) Schmidle, 286
— epiphytica Hieron., 284, 621
— *epiphytica* Wille, 284, 287, *306*
— erebi West, W. and G. S., 309
— *erecta* Setchell and Gardner, 284
— gardneri (Setchell and Gardner) Geitler, 284, *292*
— *gloiophila* Lemm., 293
— gracilis (Menegh.) Rabenh., 285, 304
— hieronymusii Lemm., *288*, 297
— — f. robusta Parukutty, 297
— — v. crassi-vaginata Ghose, 297, *316*
— — v. *major* Mitra, 297
— holdenii Forti, 286, *292*
— infixa Frémy, 282
— *iyengari* Mitra, 321
— — v. *violacea* Mitra, 321
— kashyapii Ghose, 298, *300*
— kuetzingii Schmidle, 282, *288*
— — v. *distincta* (Nordst.) Lemm., 286
— — v. minor Gardner, 284
— kuetzingiana Kirchn., 311
— lachneri (Zimm.) Geitler, 281
— lagerheimii (Mobius) Gom., *288*, 290, *306*
— — f. minor nom. nov., 291
— laxespiralis Skuja, 289, *295*
— limnetica Lemm., 294, *295*
— loriae Forti, 321
— lutea (Ag.) Gom., *304*, 310
— magnifica Gardner, 320
— major Menegh., *304*, 320
— majuscula Harv., *288*, *292*, *304*, 313, 619
— — v. chakiensis Rao, C. B., *300*, 314
— martensiana Menegh., *304*, 318

Lyngbya—(*contd.*)
— martensiana *forma* Bharadw., *300*, 319
— — *forma* Rao, C. B., 319
— — *forma* Singh, V. P., 319
— — v. calcarea Tilden, *306*, 319
— — v. minor Gardner, 319
— mesotricha Skuja, 282, *295*
— mucicola Lemm., 293
— nigra Ag., 317
— nordgardhii Wille, 287, *292*, *312*
— ochracea (Kütz.) Thuret, 301
— *pallida* Zeller, 437
— palmarum (Martens) Bruhl and Biswas, 301, *316*
— *penicillata* (Kütz.) Rabenh., v. *tripunctata* Biswas, 325
— perelegans Lemm., *288*, *306*, 309
— polysiphonae Frémy, 287, *306*
— — *forma* Singh, V. P., 287
— porphyrosiphonis Frémy, *306*, 313
— putealis Mont., *304*, 317
— rivularianum Gom., 293
— rubida Frémy, 298, *306*
— — *forma* Mitra, 299
— — *forma* Rao, C. B., 298
— — *forma* Rao, C. B., 299
— *rupestris* Ag., 276
— scotti Fritsch, 310
— semiplena (C. Ag.) J. Ag., *292*, *304*, 315, 619
— shackletoni West, W. and G. S., 296, *306*
— sordida (Zanard.) Gom., 285, *304*
— spiralis Geitler, *288*, 289
spirulinoides Gom., 289, *304*
— stagnina Kütz., 317
— — *forma* Rao, C. B., 317
— subconfervoides Borge, 321
— subtilis West, W., 294
— — v. granulosa Bruhl and Biswas, 296
— truncicola Ghose, *300*, 308
— — v. burmense Ghose, *300*, 309
— versicolor (Wartm.) Gom., *306*, 311
— *willei* Setchell and Gardner, 287
Marssoniella Lemm., 79, 80
*Mastichonema caespitosum* Kütz., 538
*Mastichothrix aeruginea* Kütz., 527
Mastigocladopsis Iyengar and Desik., 575
— fremyii nom. n., 577
Mastigocladopsis—(*contd.*)
— jogensis Iyengar and Desik., 575, 576
Mastigocladus Cohn, 580
— *flagelliformis* Schmidle, 590
— *hansgirgi* Schmidle, 590
— laminosus Cohn, 582, *583*, *584*
— — v. indicus v. nov., 581, *582*, *584*, 618
Mastigocoleus Lagerh., 573
— testarum Lagerh., 573, *574*, 575
*Merismopedia* Kütz., 80
Merismopedia Meyen, 79, 150
— aeruginea Bréb., 92, 156
— convoluta Bréb., *151*, 152
— elegans A. Br., *151*, 156
— glauca (Ehrenb.) Näg., *151*, 155, 619
— — *forma* Rao, C. S., *151*, 156
— — *forma* Gupta, 156
— — f. mediterranea (Näg.) collins, 156
— marssonii Lemm., *151*, 154
— minima Beck, *151*, 154
— — *forma* Rao, C. B., 154
— punctata Meyen, *110*, *151*, 155, 620
tenuissima Lemm., *151*, *153*, 154
— *thermalis* Kütz., 135
Microchaete Thuret, 350, 508
— aequalis (Frémy) comb. n., *427*, 513
— aeruginea Batters, *352*, 510
— calothricoides Hansg., 514
— elongata (Frémy) comb. n., *512*, 513
— grisea Thuret, 508, 510
— — v. brevis Bharadw., *509*
— loktakensis Bruhl and Biswas, *509*, 515
— tenera Thuret, 508, *509*, *512*, 513
— — *forma* Rao, C. B., 514
— — v. tenuis Bharadw., *509*, 514
— uberrima Carter, *509*, 511
— — f. *minor* Carter, *509*, 511
— violacea Frémy, 511
*Microchaete* (Thur.) Elenk.
Microcoleus Desmaz., 341
— acutissimus Gardner, *342*, 344, 621
— *aitschisonii* Schaar., 346
— brasiliensis Borge, 621
— burmanicus (Zeller) comb. n., 346
— chthonoplastes Thur., *342*, 343, 619
— — *forma* Dixit, 344
— *delicatulus* v. *attenuatus* Ghose, *336*, 344
— lacustris (Rabenh.) Farlow, *342*, 345
— — f. minor nom. n., 346

Microcoleus—(*contd.*)
— paludosus (Kütz.) Gom., *324*, 344
— sociatus West, W. and G. S., 346, 619
— subtorulosus (Bréb.) Gom., *324*, 345
— —*forma* Singh, R. N., 345
— vaginatus (Vauch.) Gom., *324*, 343
Microcrocis Richt., 80
Microcystis Kütz., 79, 81
— aeruginosa Kütz., 82, *86*, *88*, 93, 619, 620
— — v. *elongata* Rao, C. B., *90*, 94
— — v. *major* (Wittr.) Smith, *86*, 93
— angulata Zal., 82
— bengalensis Banerji, 89, *90*
— caerulea Dickie, 82
— *donnellii* Wolle, 83
elabens (Bréb.) Kutz., *88*, *92*, 97
— — v. *major* Bachm., 97
— elabentoides Zal., 82
exigua Zal., 82
— elongata sp. n., *88*, 89, 617
— floccosa Zal., 82
— flos-aquae (Wittr.) Kirchn., 82, 83, *86*, *88*, 94, 620
— — v. *robusta* Nygaard, 85
— fusca Zal., 82
glauca (Wolle) Dr. and D., 82
— globosa Zal., 82
holsatica Lemm., 82
— ichthyoblabe Kutz., 82
— firma (Bréb. and Lenom.) Schmidle, 82
— incerta Lemm., 82
— insignis (Beck) comb. n., 98
— lamelliformis Holsinger, *90*, 91
— litoralis (Hansg.) Forti, 85
— marginata (Menegh.) Kütz., 83, 86
— minutissima West, W., 83
— *olivacea* Kütz., 83
— ochracea Lemm., 82, 83
— orissica West, W., 92, 97
— pallida Migula, 82
— parasitica Kütz., 83
— prasina Lemm., 82
— protocystis Crow, 82, 83, 91, *92*
— pseudofilamentosa Crow, 82, 83, *88*, *92*, 94, 620
— pulverea (Wood) Forti, 83
— — f. elongata Crow, 83
— — v. incerta (Lemm.) Crow, 97
— ramosa Bharadw., 82, *90*, 95

Microcystis—(*contd.*)
— robusta (Clark) Nygaard, 82, 85
— scripta (Richter) Lemm., 83, 91, *92*, 620
— —*forma* Rao, C. S., 93
— stagnalis Lemm., 82, 95
— viridis (A. Br.) Lemm., 82, 83, 87, *88*
— (Kütz.) Elenk., 79
— *aeruginosa* (Kütz.) Elenk., 82
— — f. *aeruginosa* (Kütz.) Elenk., 83
— — f. *flos-aquae* (Wittr.) Elenk., 83, 94
— — f. *marginata* (Menegh.) Elenk., 83, 87
— — f. *ochracea* (Brand) Elenk., 83
— subg. *Aphanocapsa* (Näg.) Elenkin, 82
— subg. *Capsothece* Elenkin, 79
— subg. *Endobiotica* Elenkin, 82
— subg. *Eucoccochloris* (Kirchn.) Elenkin, 79
— subg. *Eumicrocystis* Elenkin, 79, 82
— — f. *protocystis* (Crow) Elenk., 83, 91
— — f. *pseudofilamentosa* (Crow) Elenk., 83, 94
— — f. *scripta* (Richter) Elenk., 83, 91
— — f. *sphaerodictyoides* Elenk., 83, *96*
— — f. *viridis* (A. Br.) Elenk., 83, 87
— *pulverea* (Wood) Elenk., 82, 83, 96
— — f. *holsatica* (Lemm.) Elenk., 83, 96
— — f. *incerta* (Lemm.) Elenk., 83
— — f. *parasitica* (Kutz.) Elenk., 83
— — f. *minor* (Lemm.) Hollerb., 83
— — f. *pulverea* Elenk., 83, 96
— — f. *stagnalis* (Lemm.) Elenk., 83, 95
*Microhaloa elabens* Bréb., 97
*Monocapsa* Itzigs., 80
Myxosarcina Printz, 80, 178
— burmensis Skuja, *164*, 178
— concinna Printz, 178, 619
— spectabilis Geitler, *153*, *161*, 178
Myxobactron Schmidle, 79
*Nematonostoc* Elenk., 350
Nodularia Mertens, 350, 423
— *fertilissima* Randhawa, 424
— spumigena Mertens, 423, 425
— — v. major (Kütz.) B. & F., *352*, 423
Nostoc Vaucher, 350
— amplissimum Setchell, 390
— calcicola Bréb., *379*, 384
— carneum Ag., 381, *382*
— — f. minor Bharadw , 383
— coeruleum Lyngb., 388, 621
— commune Vaucher, 373, *378*, 387, 619, 621

Nostoc—(*contd.*)
— ellipsosporum (Desm.) Rabenh., *382*, 383, 621
— — v. *vaginis-achromatices*, 383
— — v. *violacea* Rao, C. B., *378*, 383
— entophytum Born. and Flah., 375
— *granulare* Rabenh., 384
— *gregarium* Thuret, 388
— hatei Dixit, *376*, 389
— *hedurulae* Martens, 374
— heterothrix Zeller, 391
— humifusum Carm., 384
— — v. fluitans West, W. and G. S., 384
— *kurzianum* Zeller, 387
— limosum Zeller, 391
— linckia (Roth) B. and F., 377, 380, *382*, 619
— — v. arvense Rao, C. B., *376*, 377
— — v. *globispora* Mitra, 377
— maculiforme B. and F., 374
— microscopicum Carm., 387, 621
— muscorum Ag., 385, *386*, 621
— paludosum Kutz., 375, *382*, 619
— —*forma* Mitra, 377
—*forma* Rao, C. B., 375
— v. *major* Mitra, 377
— parmelioides Kütz., *386*, 389
— passerinianum (De Not.) Born., 385
— piscinale Kutz., 377, *382*
— —*forma* Rao, C. B., 379
— pruniforme (L.) Ag., 390
— punctiforme (Kutz.) Hariot, 374
— — v. *populorum* Geitler, *382*
— *purpurascens* Kütz., 381
— rivulare Kütz., 379
— *saxatile* Zeller, 379
— sphaericum Vaucher, 390
spongiaeforme Ag., 380
— — v. tenue Rao, C. B., *378*, 380
— — v. varians Rao, C. B., *376*, 381
— tenuissimum Born., 375
— verrucosum Vaucher, *386*, 388
Nostochopsis Wood em. Geitler, 568
— hansgirgi Schmidle, *571*, 572
— lobatus Wood em. Geitler, *569*, 570
— radians Bharadw., *571*, 572
— *rupestris* Schmidle, 572
*Oncobyrsa* Ag., 180
— *rivularis* (Kütz.) Menegh., 181
Oncobyrsa—(*contd.*)
—*fluviatilis* (Kütz.) Menegh., 180
*Oscillaria* Pollini
— *antillarum* Kütz., 242
— *antilaria* Mert., 276
— *antliaria* Jurgens f. *physoides* Rabenh., 276
— *irrigua* Kütz., 224
Oscillatoria Vaucher, 198
— *acula* Bruhl and Biswas, 212, 241
— acuminata Gom., *208*, *214*, 240, 619
— —*forma* Dixit
— —*forma* Rao, C. B.
— — f. *tenuis* Parukutty, 240
— acuta Bruhl and Biswas orth. mut. Geitler, 212, 240
— acutissima Kuff., 237
— agardhii Gom., 235
— amoena Gom., *214*, *220*, 230
— — v. nongranulata Ghose, *212*, 230
— amphibia Ag., *204*, 229
— amphigranulata Van Goor, *204*, 226
— anguina (Bory) Gom., *208*, 210
— —*forma* Skuja, 211, *220*
— angusta Koppe, 227
— angustissima West, W. and G. S., 227
— animalis Ag., *214*, 239
— — f. *tenuior* Stockmeyer, 240
— annae Van Goor, 203, 208
— antillarum Kütz., 242
— *articulata* Gardner, 216
— — f. *tenuis* Parukutty, 216
— borneti Zukal, 221
— boryana Bory, *208*, 218
— brevis (Kütz.) Gom., 241
calcuttensis Biswas, 237, *244*
— —*forma* Rao, C. B., 237
— chalybea (Mertens) Gom., *208*, 218, 619
— — v. insularis Gardner, 208, 219
— chilkensis Biswas, *212*, 215
— chlorina Kütz., *214*, 215
— claricentrosa Gardner, *214*, 231
— — f. bigranulata Rao, C. B., *212*, 231
— corallinae (Kütz.) Gom., *214*, 221
— cortiana Menegh., *208*, 233
— cruenta Grun., 241
— curviceps Ag., *208*, 209
— —*forma* Parukutty, 209
— —*forma* Rao, C. B., 209, *212*
— — v. angusta Ghose, 210, *212*

Oscillatoria (*contd.*)
— decolorata West, G. S., 221
— deflexa West, W. and G. S., 236
— — v. crassa Woronichin, 236
— earlei Gardner, *208,* 238
— *erythrea* (Ehrenb.) Geitler, 196
— foreaui Frémy, *214,* 219
— formosa Bory, *214,* 232, 619
— —*forma* Rao, C. B., 232
— — f. loktakensis Bruhl and Biswas, *212,* 233
— fracta Carlson, 619
— fremyii De Toni, 225
— *geitleri* Frémy, 230
— geitleriana Elenkin, *214,* 230
— geminata Menegh., 621
— gloiophila Gom., 225
— granulosa Martens, 242
— grunowiana Gom., 216
— — v. articulata (Gardner) Drouet, 216
— hamelii Frémy, 225, 621
— —*forma* Skuja
— *hildebrandtii* (Gom.,) Geitler, 245
— *homogenea* Frémy, *214,* 217
— interrupta Corda, 243
— interrupta Martens, 243
— irrigua Kutz., 224, *244*
— jasorvensis Vouk, 221
— —*forma* Gonzalves, 222
— juliana Menegh., 242
— kuetzingiana Näg., 237
— kurziana Martens, 243
— *lachneri* Zimm., 281
— *lacustris* (Kleb.) Geitler, 246
— laete-virens Gom., 213
— — v. minimus Biswas, *212,* 213
— lemmermannii Wolosz., 214, 237
— limnetica Lemm., *204,* 226
— limosa Ag., 206, *208, 244*
— — v. constricta Biswas, 207
— margaretifera Kütz., 202, *244*
— martini Frémy, *208,* 216
— —*forma* Rao, C. B., 216
— miniata (Zanard.) Hauck, 202, *214*
— minnesotensis Tilden, 214, 225
— mougeotii Kütz., 222
— *neglecta* Lemm., 225
— nigra Vaucher, 223
— nigro-viridis Thwaites, 202, *244, 292*

Oscillatoria—(*contd.*)
— obscura Bruhl and Biswas, 207, 619
— okeni Ag., *208,* 231
— ornata Kütz., *204,* 206, *214,* 621
— — v. crassa Rao, C. B., 206, *212, 220*
— paucigranata Bruhl and Biswas, 238
— perornata Skuja, 205, *220*
— — v. attenuata Skuja, 205, *220*
— princeps Vaucher, *204,* 210, 621
— — v. pseudolimosa Ghose, 210, 212
proboscidea Gom., 208, 211, 621
— —*forma* Gonzalves, 211
— prolifica (Grev.) Gom., 234
— proteus Skuja, *220,* 221
— pseudogeminata Schmid, G., *220,* 228
— —*forma* Rao, C. B., 229
— —*forma* Rao, C. S., 229
— — v. unigranulata Biswas, *212, 220,* 229
— quadripunctulata Bruhl and Biswas, *204,* 227, 619
— — v. unigranulata Singh, R. N., 327, 328, 621
— raciborskii Wolosz., *204,* 236, 619
— raoi De Toni, 223, *244,* 619
— rubescens D. C., 235, *244,* 619
— —*forma* Rao, C. B., 235
— — f. *minor* f. n., *204*
— salina Biswas, 239, 619
— — f. major f. n., *204,* 239, 618
— sancta (Kütz.) Gom., 203, *244,* 619
— —*forma* Dixit, 203
— —*forma* Rao, C. B., 203
— — f. *tenuis* Parukutty, 203
— schultzii Lemm., *220,* 232, 621
— serpentina Richter, 242
— simplicissima Gom., 224
— —*forma* Holsinger, 224
— splendida Grev., *204, 208, 214,* 234, 621
— — v. attenuata West, W. and G. S., 234
— — v. *limnetica* (Lemm.) Playfair, 226
— subbrevis Schmidle, *204,* 207, *214,* 619
— —*forma* Dixit, 207
— — f. crassa Dixit, 209
— — f. major West, G. S., 209
— — f. minor f. n., 209, 618
— subproboscidea West, W. and G. S., 238
— *subsalsa* Ag., 219
— subtilissima Kütz., 215
— subuliformis Kütz., 213, *292*

Oscillatoria (*contd.*)
— tambi Woronichin, 621
— tanganyikae West, G. S., *214,* 233
— tenerrima Lyngb., 243
— tenuis Ag., *208,* 222, *244*
— — v. *chlorina* (Kütz.) Playfair, 215
— — v. natans Gom., 223
— — v. tergestina Rabenh., 223, *244*
— terebriformis Ag., *208,* 217, 619
— — var. (?) Skuja
— *thiebautii* (Gom.) Geitler, 245
— trichoides Szafer, *220,* 228
— — var. (?) Szafer, 228
— *variabilis* Rao, C. B., 223, 619
— —*forma* Rao, C. B., 224
—*forma* Singh, R. N., 224
— versicolor Martens, 241
— violacea (Wallr.) Hass.
— *viridis* Vaucher, 222
— viridula Zeller, 242
— vizagapatensis Rao, C. B., 205, *212*
— *willei* Gardner, 217
— willei Gardner em. Drouet, *208, 214,* 217
Petalonema (Berk.) B. and F., 506
— alatum Berk., 506
— v. indicum Rao, A. R., 507
*crustaceum* (Ag.) Kirchner, 487
— densum (A. Br.) Migula, *496,* 507
Phormidium Kütz., 250
— abronema Skuja, 257, 436
— africanum Lemm., 254
— ambiguum Gom., *264,* 266, *270,* 619
— —*forma* Rao, C. B., 266
— — v. major Lemm., 266
— angustissimum West, W. and G. S., 253
— — *forma* Mitra, 253
— anomala Rao, C. B., 266, *270,* 621
— autumnale (Ag.) Gom., *264,* 276
— —*forma* Rao, C. B., 276
— bigranulatum Gardner, 261
— bohneri Schmidle, 261
— —*forma* Rao, C. B., 261
— — —*forma* Rao, C. B., 262
— calcicola Gardner, *260,* 267
— cebennense Gom., 262
— ceylanicum Wille, *260,* 272
— cincinnatum Itzigs., 621
— corium (Ag.) Gom.; *264,* 269
Phormidium—(*contd.*)
— — v. capitatum Gardner, *260,* 271
— — — f. *terrestris* Mitra, 271
— dimorphum Lemm., 256, *312*
— favosum (Bory) Gom., *264,* 275
— —*forma* Rao, C. B., 275
— foveolarum Gom., 254
— fragile (Menegh.) Gom., 253, *264*
— —*forma* Mitra, 253
— hansgirgi Schmidle, 272
— hieronymusii Lemm., 269
— — f. *major* Mitra, 269
— incrustatum (Näg.) Gom. *264*
inundatum Kütz., 271
— jadinianum Gom., 256
— —*forma* Rao, C. B., 257
— jenkelianum Schmid, G., 255, *312, 316,* 619
— *ladinianum* Gom. ex Ghose, 256
— laminosum Gom., 259, *264*
— lucidum (Kütz.) Gom., 250, *264,* 275
— — *forma* Skuja, 275
— luridum (Kütz.) Gom., 263, 619
— lyngbyaceum Kütz.,
— microtomum Frémy, 257, 260
*minnesotensis* (Tilden) Drouet, 225
— moerlianum Grun., 277
— molle (Kütz.) Grun., 255, *336*
— f. tenuior West, G. S., 255
— mucicola Hub.-Pest. and Naumann, 254
— —*forma* Skuja, 254
— mucosum Gardner, *260,* 265
— — v. arvense Rao, C. B., 265, *336*
— obscurum Kütz., 311
— orientale West, G. S., 263
— oryzetorum Martens, 277
— pachydermaticum Frémy, *260,* 267
— —*forma* Rao, C. B., 267
— papyraceum (Ag.) Gom., 271
— *papyrinum* Kütz.
— purpurascens (Kütz.) Gom., 262, *264, 270*
— *quadripunctulatum* (B. and B.) Gardner, 227
— retzii (Ag.) Gom., *264,* 268, 619
— — f. major Parukutty, 268
— rotheanum Itzigs., 258
— — v. capitatum Desik. nom. n. 258, *270*
— rubriterricola Gardner, *260,* 261
— solitare (Kütz.) Rabenh., 278

Phormidium—(*contd.*)
— stagnina Rao, C. B., 265, 270
— subfuscum Kütz., 264, 273
— — v. joannianum (Kütz.) Gom., 273
— — v. luteofuscescens Rabenh., 273
— subincrustatum Fritsch and Rich, 267, 621
— submembranaceum (Ard. and Straff.) Gom., *264*, 273
— tenue (Menegh.) Gom., 259, *260, 264*
— — v. *indica* Mitra, 259
— truncicola Ghose, 258, *336*
— uncinatum (Ag.) Gom., *260, 270,* 276
— usterii Schmidle, 257
— valderianum (Delp.) Gom., 263, *264*
Pilgeria Schmidle, 79, 80
Placoma Schousboe, 160
— africana Wille, 162
— vesiculosa Schousboe, *139*, 162
Planosphaerula Borzi, 80
Plectonema Thuret, 434
— dangeardii Frémy, *324*, 440
— gracillimum (Zopf) Hansg., 441
— hansgirgi Schmidle, 439
— indica Dixit, 435, *436*
— —*forma* Rao, C. B., 437
— *malayense* Biswas, 441, 442
— nostocorum Born., 436, 439
— — f. discolor Cedercruetz, 440
— notatum Schmidle, *436*, 440
— — v. africanum Fritsch, 441
— puteale (Kirchn.) Hansg., 439
— radiosum (Schiederm.) Gom., *436,* 437
— terebrans Born. and Flah., *352*, 435
— thomasinianum (Kütz.) Born., *436*, 438
— — v. vandalurense var. nov., *333*, 438, 618
— — v. graciles Hansg., 438
— wollei Farlow, *436*, 437
*Pleurococcus* Menegh., 80
*Pleurocapsa concharum* Reinsch, 180
Polychlamydum West, W. and G. S., 249
— insigne West, W. and G. S., 249, *283*
— varium Ghose, 249, *274*
*Polycystis* Kütz., 80
— *aeruginosa* Kütz.
— *elabens* Kütz., 97
— *elongata* West, W and G. S., 83
— *insignis* Beck, 82, 98
— *litoralis* Hansg., 85
Polycystis—(*contd.*)
— *scripta* Richter, 91
— *stagnalis* Lemm., 95
Porphyrosiphon Kütz., 248
— fuscus Gom. ex Frémy, 248
— notarisii (Menegh.) Kütz., 248, *283,* 619
*Protococcus pallidus* Näg., 109
Pseudanabaena Lauterb., 349, 419
— catenata Lauterb., 419
— *constricta* (Szafer) Lauterb., *394,* 419
— schmidlei Jaag, *404,* 419
— — f. gracilis Skuja, 420
— — f. robusta Skuja, 419
*Pseudoholopedium* (Rypowa) Elenkin, 79
— *convoluta* (Bréb.) Elenk.,
Pseudoscytonema Elenkin, 441
— malayense (Biswas) Elenkin, 442, *480*
Raphidiopsis Fritsch and Rich, 420
— curvata Fritsch and Rich, 365, 420, *42*
— —*forma* Holsinger, 422
— indica Singh, R. N., *421,* 422
— mediterranea Skuja, *421,* 422
Rhabdoderma Schmidle and Lauth., 79 80, 145
— gorskii Wolosz., *126*, 145
— lineare Schmidle and Lauterb., 145
— sigmoidea Carter f. minor Carter, 620
Rhabdogloea Schroeder, 80
Radiocystis Skuja, 80
Richelia Schmidt, Joh., 349, 351
— intracellularis Schmidt, 351, *352,* 353
— —*forma* Iyengar and Desik., 353
Rivularia (Roth) Ag., 548
— aquatica De Wilde., *550,* 552
— beccarina (De Wilde) Geitler, 518, *550* 551
— bullata Berk., 549
— dura Roth, 548, 551
— — v. confluens Frémy, 551
— globiceps West, G. S., 552
— —*forma* Rao, C. B., 553
— hansgirgi Schmidle, 536, 549
— *lens* Manegh., 556
— manginii Frémy, *518, 530,* 548, 552
— — v. confluens Frémy, 552
— *natans* (Hedw.) Welwitsch., 561
— peguana Zeller, 553
*Schizopsiphon parietinus* Näg. ( = *Calothrix parietina*), 538

Schizothrix (Kütz.) Gom., 321
— aeruginea (Rabenh.) comb. n., 334
— — v. subtorulosa (Zeller) comb. n., 334
— arenaria (Berk.) Gom., 327
— — v. *non-constricta* Ghose, 327, *336*
— beccarii Gom., 329
— confervae (Kütz.) comb. n., 334
— delicatissima West W. and G. S., 327
— ericetorum Lemm., 332, *333*
— fragilis (Kütz.) Gom., 328
— friesii (Ag.) Gom., 328, *331*
— — f. repens Frémy, 328
— fuscescens Kütz., 322, 332, *333*
lacustris A. Br., *324*, 325
— lamyi Gom., *324*, 330
— lardacea (Ces.) Gom., 327
lateritia (Kütz.) Gom., 326
— mexicana Gom., 323
— muelleri Nag., 330, *331*
— — f. *lyngbyacea* Gom., 330
— penicillata (Kütz.) Gom., 323
— porphyromelana (Bruhl and Biswas) Geitler, 326
— pulvinata (Kütz.) Gom., 323
— purpurascens (Kütz.) Gom., 329, *331*
— — v. *cruenta* Gom., 329
— subundulata (Martens) comb, n., 332
telephoroides (Mont.) Gom., 330, *331*
tenax (Wolle) comb. nov., 334
tenuis Woronichin, 329, 619
vaginata (Näg.) Gom., 325, *333*
— — v. nongranulata Ghose, 326, *333*
— viridula (Zeller) comb. nov., 334
*Schmidleinema* De Toni, 596
— *indicum* (Schmidle) De Toni, 598
Scopulonema Erceg., 179
— concharum (Hansg.) Geitler, 180
— hansgirgianum Erceg., 180
Scytonema Ag., 450
— aerugineo-cinereum Kütz., 491
— *alatum* (Carm.) Borzi, 506
— amplum West, W. and G. S., *462*, 469
— *aureum* Menegh., 489
— bewsii Fritsch and Rich, *470*, 481
— bohneri Schmidle, *454*, 457
— burmanicum Skuja, 460
— caldarium Setchell, 458
— chiastum Geitler, 453, *464*
— — f. minor Parukutty, 453
Scytonema—(*contd.*)
— cincinnatum Thuret, 453, 473
— *chlorophaeum* Kütz., 487
— — f. *tenuis* Martens, 487
— *cinereum* Menegh., 467
— — v. *julianum* Rabenh., 472
— coactile Mont., 455, *464*
— — *forma* Skuja, 457
— crassum Näg., 489
— *crispum* (Ag.) Born., 453
— crustaceum Ag., *456*, 485, *488*
— dilatatum Bharadw., *462*, 465
— — f. major Bharadw., 467
— *figuratum* Ag., 483
— frémyii nom. n., 474, *492*
— fritschii Ghose, 458, *480*
— — *forma a* Bharadw., 458
— — *forma b* Bharadw., 458
— fulvum Zeller (= *Porphyrosiphon notarisii*), 248
— fuscum Zeller (= *Porphyrosiphon notarisii*), 248
geitleri Bhardw., *477*, 481
— — v. tenuis Bharadw., 481
— *gracile* Kutz., 487
— granulatum Martens, 491
— guyanense (Mont.) B. and F., 469, *470*, 620
— — v. minus Gardner, *454*, 471
— — v. prolifera Bharadw., *462*, 471
— hansgirgi Schmidle, 463
— hofmanni Ag., *466*, 476, 619
— — v. calcicolum Hansg., 476
— v. crassa Bharadw., *477*, 478
— — v. symplocoides (Reinsch) B. and F., 478
— iyengari Bharadw., *462*, 465
— — *forma* Singh, V. P.,
— javanicum (Kütz.) Born., 461, *492*, 620
— julianum (Kütz.) Menegh., 454, 472
— *kurzianum* Zeller, 476
— leptobasis Ghose, 457
— maculiforme Schmidle, 491
— malaviyaensis Bharadw., *449*, 483
— millei Born., 460, *473*
— — *forma* Bharadw., 460, *486*
— mirabile (Dillwyn) Born., *466*, 483, *486*, 619
— — *forma* Bharadw., 485

Scytonema—(*contd.*)
— — f. minor Bharadw., 485, *486*
— — v. *amplum* (West and West) Playfair, 469
— multiramosum Gardner, 470, 475
— — v. ceylonica Bharadw., 475, *477*
— *murale* Zeller, 467
— myochrous (Dillw.) Ag., *464*, 487, *488*
— —*forma* Bharadw., 489
— *natans* Bréb., 438
— ocellatum Lyngb., 467, *470*, 619, 621
— —*forma* Bharadw., 467
— — f. minor Bharadw., 467
— — v. capitatum Ghose, 467, 480
— — v. purpureum Gardner, 467
— olivaceum Zeller, 490
— *palmarum* Martens, 301
— parvulum Zeller, 491
— pascheri Bharadw., *462*, 463, 620
— pseudoguyanense Bharadw., 462, 472
— —*forma* Bharadw., 472
— pseudohofmanni Bharadw., *477*, 478
— —*forma* Bharadw., 479
pseudopunctatum Skuja, 469, *482*
— rhizophorae Zeller, 490
— rivulare Borzi, 452, *492*
— saleyeriense Bosse, 461
— — v. indica Bharadw., 461, 462
— schmidlei De Toni, 474
— schmidtii Gom., 459, *470*
— simplex Bharadw., 455, *462*
— stuposum (Kütz.) Born., 459, *473*, 619
— subclavatum Zeller, 491
— subtile Möb., *456*, 475
— *tenuissimum* Frémy, 474
— *tenuissimum* Schmidle, 474
— tolypothrixhoides Kütz., *456*, *466*, 479
— — f. terrestris Bharadw., 479
— *tomentosum* Kütz., 487
— *turfosa* Kütz., 487
— varium Kütz., 474
— viellardi Martens
— violacens Zeller, 490
— zellerianum Bruhl and Biswas, *480*, 489
Scytonematopsis Kissel., 447
— kashyapi (Bharadw.) Geitler, 448, *449*
— woronichinii Kissel., 447, 448
Seguenzaea anthonyii Gupta, 602, *615*
Sirocoleus Kütz., 340
Sirocoleus—(*contd.*)
— guyanense Kütz., 340
— indicus Zeller, 341
— kurzii (Zeller) Gom., *283*, 340
*Sirosiphon pulvinatus* Bréb., 609
*Skujaella* De Toni J., 243
— *eythraea* (Ehrenb.) De Toni, 246
— *thiebautii* (Gom.) De Toni, 245
— *hildebrantii* (Gom.) De Toni, 245
*Snowella* Elenk., 79, 80, 146
*Sorospora* Hass., 80
*Spelaeopogon kashyapi* Bharadw., 448, *449*
*Sphaeronostoc* Elenk., 350
— *coeruleum* (Lyngb.) Elenk., 389
Spirulina Turpin, 79
— gigantea Schmidle, *194*, 197
— *gomontiana* (Setchell) Geitler, 192
— — v. *crassa* Gupta (= *Arthrospira gomontiana* v. *crassa* (Gupta) comb. nov., 192
— *jenneri* (Stizb.) Geitler, 192
— labyrinthiformis (Menegh.) Gom., *194*, 195, *292*
— laxa Smith, 621
— laxissima West, G. S., *194*, 196
— — f. major f. nov., *194*, 196, 618
— major Kütz., *194*, 196
meneghiniana Zanard., *194*, 195
— nordstedtii Gom., 621
— oscillarioides Turpin, 198
— *platensis* (Nordst.) Gom., 190
— — v. *tenuis* Rao, C. B., 190
— — v. *con-constricta* Banerji, 191
— princeps West, W. and G. S., 187, *194*, 197
— *spirulioides* (Ghose) Geitler, 189
— — f. *tenuis* Singh, R. N., 189
— subsalsa Oerstd., 193, *194*, 621
— subtilissima Kütz., *194*, 196
— *tenuis* (Bruhl and Biswas) Geitler, 191
— *tenuissima* Kütz., 193
— *tenuissima* Nordst. (= sp. major Kütz.), 196
— turfosa Cram., 193
Stauromatonema Frémy, 567
— viride Frémy, *566*, 567
Stichosiphon Geitler, 176
— *filamentosus* (Ghose) Geitler, 176, 177
— *indicus* Rao, C. B., 176, 177, 620

Stichosiphon—(*contd.*)
— —*forma* Singh, R. N.. 176
— — v. *tenuis* Gupta, 177
— *regularis* Geitler, 176
— sansibaricus (Hieron.) Dr. and D., *164*, *170*, 172, 176, 620
Stigonema Ag., 603
— aerugineum Tilden, *566*, 606
— dendroideum Frémy, *608*, 609, *612*
— hormoides (Kütz.) B. and F., 604, *605*
— *indicum* Schmidle, 598
— informe Kutz., *612*, 613
— lavardei Frémy, *610*, 611
— — v. indica Frémy, 613
— mamillosum (Lyngb.) Ag., *608*, 613
— mesentericum Geitler, *605*, 607
— minutum (Ag.) Hass., 611, *612*
— — f. dumetosa Frémy, 613
— — v. *saxicola* (Näg.) B. and F., 611
— ocellatum (Dillw.) Thuret, 607, *614*
— — f. *panniforme* (Ag.) Elenk., 607
— — f. *tomentosum* (Kütz.) Elenk., 607
— *panniforme* (Ag.) Born. and Flah., *605*, 606
— panniforme (Ag.) Kirchner, 606, *614*
— *pulvinatus* (Bréb.) Borzi, 609
— *saxicola* Nag., 611
— *tenue* (Martens) Born. and Flah., 602
— tomentosum (Kutz.) Hieron., 606
— turfaceum (Berk.) Cooke, 609
— *turfaceum* (Link) Cooke, 609
*Stratonostoc* Elenk., 350
— *commune* (Vaucher.) Elenk., 387, 390
— *linckia* (Roth) Elenkin, 379, 381
— — f. *calcicola* (Bréb.) Elenk. (= N. calcicola), 384
— — f. *carneum* (Ag.) Elenk. (= N. carneum), 381
— — f. *ellipsosporum* (Desmaz.) Elenk. (= N. ellipsosporum), 383
— — f. *humifusum* (Carm.) Elenk. (= N. humifusum), 384
— — f. *linckia* (Roth.) Elenkin (= N. linckia), 379
— — f. *muscorum* (Ag.) Elenk. (= N. muscorum), 387
— — f. *passerinianum* (Born. et Thur.) Elenk. (= N. pessarinianum), 385
— — f. *piscinale* (Kütz.) Elenk. (= N. piscinale), 377
*Stratonostoc*—(*contd.*)
— — f. *rivulare* (Kütz.) Elenk. (= N. rivulare), 379
— — f. *spongiaeforme* (Ag.) Elenk., 380
— *verrucosum* (Vauch.) Elenk., 388
— — f. *parmelioides* (Kütz.) Elenk. (= N. parmelioides), 389
Symploca Kütz., 334
— cartilaginea (Mont.) Gom., *336*, 339
— elegans Kütz., 338
— —*forma* Skuja, 338
— flaccida Zanard., 338
— hydnoides Kütz., 335, *342*
— — f. minor Iyengar and Desik., *292*, 335
— kurziana Zeller, 340
— laete-virides Gom., 335
— lutescens Zeller, 340
— muralis Kutz., 334,
— —*forma* Rao, C. B., 338
— — v. minor Gardner, *336*, 338
— muscorum (Ag.) Gom., *336*, 337, 619
— parietina (A. Br.) Gom., 339
— thermalis (Kütz.) Gom., 339
Synechococcus Näg., 79, 143
— aeruginosus Nag., *126*, 143, 144
— cedrorum Sauv., 144, 619
— elongatus Näg., *126*, 143
—*fuscus* Zeller, 143
*Synechococcus* (Näg.) Elenk., 79
— subg. *Eusynechoccus* (Näg.) Elenk., 79
— subg. *Synechocystis* (Sauv.) Elenk., 79
Synechocystis Sauv., 79, 144
— aquatilis Sauv., *126*, 144, 620
— pevalekii Erceg., *126*, 144, 620
— salina Wislouch., 144
*Tetrapedia* Reinsch, 79, 80
—*foliacea* Turner, 80
— *gothica* Reinsch, 80
— *reinschiana* Arch., 80
— *wallichiana* Turner, 80
Tetrarcus Skuja, 80
Thamniastrum Reinsch, 80
Thaumaleocystis Trevis., 80
Tolypothrix Kütz., 493
— arenophila West, W. and G. S., 504
— binata Zeller, 505
— bouteillei (Bréb. and Desm.) Forti, *496*, 499, *501*
— *bouteillei* (Bréb. and Desm.) Lemm., 500

Tolypothrix—(*contd.*)
— byssoidea (Berk.) Kirchn., 501, 502
— campylonemoides Ghose, 480, 502
— ceylonica Schmidle, 500
— conglutinata Borzi, 503
— — v. colorata Ghose, 480, 503
— crassa West, W. and G. S., 504
— distorta Kütz., 493, 495, 498
— — v. penicillata (Ag.) Lemm., *496*, 497, *498*
— — v. samoensis Wille, 497
— foreaui Frémy, *492*, 504
— fragilis (Gardn.) Geitler, 500, *501*
— *inflata* Ghose, 495
— lanata Wartm., 494, 495
— — f. *minor* Dixit, 494
— — *forma* Rao, C. B., 494
— limbata Thuret, *501*, 505
— — var. cylindrica Ghose, 505
— lophopodellophila West,
— magna Bharadw., *486*, 503
— *muscicola* Kütz., 494
— nodosa Bharadw., *486*, 494, 505
— *penicillata* (Ag.) Thur., 497
— phyllophila West, W. and G. S., 499
— rechingeri (Wille) Geitler, *501*, 503
— robusta Gardner, *498*, 499
— — *forma* Rao, C. B., 499
— rupestris Wolle, 621
— *tenuis* Kütz., 494, *498*
— tenuis (Kutz.) J. Schmidt, 494
— f. *aegagrophia* (Kütz.) Kossinsk., 495
— — f. *lanata* (Wartm.) Kossinsk., 495
— — f. *polymorpha* (Lemm.) Kossinsk., 495
— — f. *tenuis* (Kütz.) Kossinsk., 495
— — f. *terrestris* Boye-Peter., 495
Trichodesmiusm Ehrenb., 243
— erythraeum Ehrenb., *244*, 245, *292*
— *ehrenbergii* Mont., 245
— hildebrantii Gom., *244*, 245
— *indicum* Lemm., 245
— lacustre Klebahn., *244*, 246
— thiebautii Gom., 243, *244*
Westiella Borzi, 594
— intricata Borzi, 594
— lanosa Frémy, 594, *610*
Westiellopsis Janet, 596
— prolifica Janet, *595*, 596
Wollea Born. and Flah., 350, 370
— *ambigua* (Rao) Singh, R. N., 370, 400
— bharadwajae Singh, R. N., *371*, 372
— — *forma* Prasad, 372, *399*
— *cylindrica* (Ghose and Randhawa) Singh, R. N., 370
— *epiphytica* (Ghose and Randhawa) Singh, R. N., 370
— saccata (Wolle) Born. and Flah., 370
— *vaginicola* (Fritsch and Rich) Singh, R. N., 370
*Woronichiana* Elenk., 79, 80
— *naegeliana* (Ung.) Elenk., 146
Xenococcus Thuret, 181
— acervatus Setchell and Gardner, *161*, 182
— chaetomorphae Setchell and Gardner, *161*, 182
— cladophorae (Tilden) Setchell and Gardner, *161*, 183
— kerneri Hansg., *161*, 181
— schousboei Thuret, 181
— willei Gardner, 619